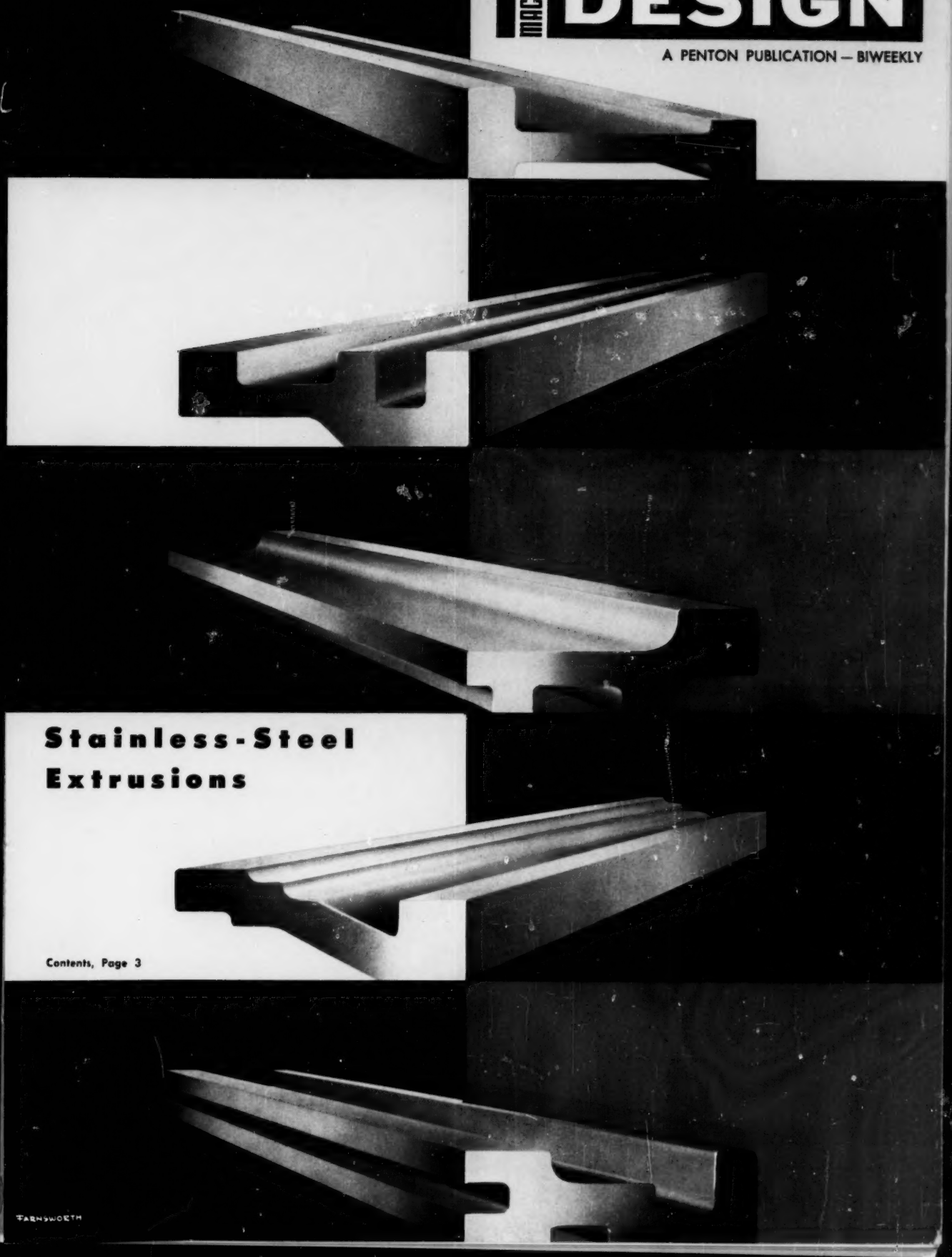
JANUARY 8, 1959

MACHINE DESIGN

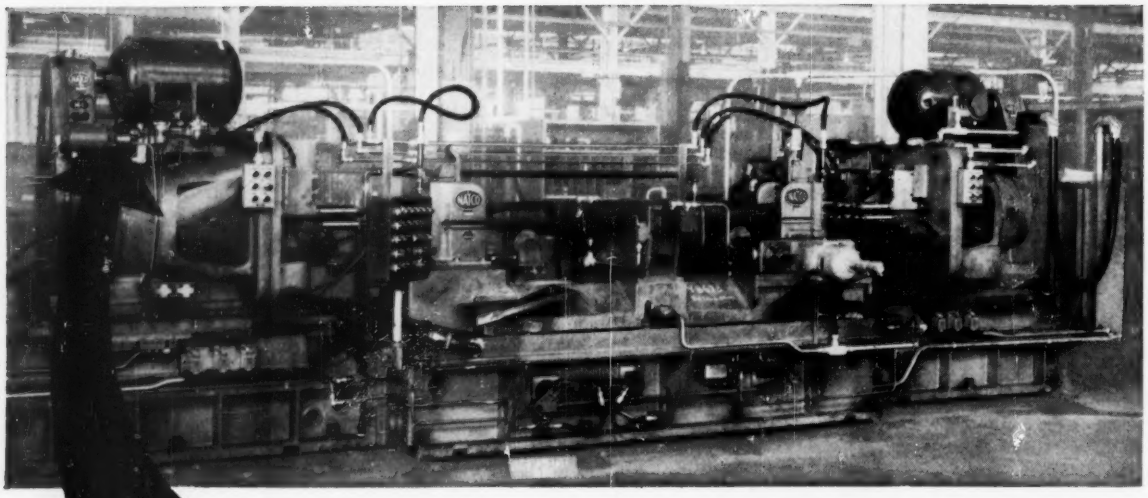
A PENTON PUBLICATION — BIWEEKLY



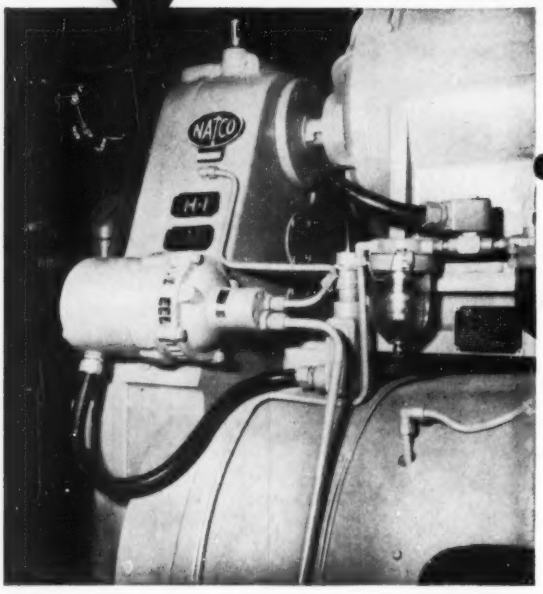
Stainless-Steel Extrusions

Contents, Page 3

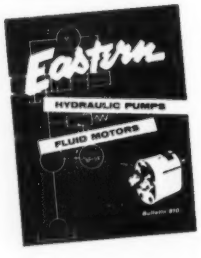
FARNSWORTH



custom hydraulic power ...off the shelf



Shown is one of two close-coupled Eastern 100 Series Pumps installed on this machine made by National Automatic Tool Company. The positive displacement gear pumps provide a cascade oil bath to lubricate the gears inside the gear chest housings. Fourteen railroad axles per hour are completed by this giant machine. It drills, spot-drills for chamfer, and taps holes of three different sizes on each end of the axle.



129 STANDARD PUMP-MOTOR COMBINATIONS BY EASTERN

This broad array of pump and motor combinations should meet *your* hydraulic power needs. Typical uses include power for machine tools, automatic door openers, material handling equipment, and thousands of other applications requiring smooth, dependable hydraulic power.

With a performance range from .1 to 9.8 G.P.M. at pressures to 2000 P.S.I., you get a versatile selection of power source. Many types of motors offer a choice of electrical characteristics, and have drip-proof, totally enclosed, or explosion-proof enclosures as required.

When you need custom equipment, why get involved with unnecessary research expense? Call Eastern and discover how this adaptable line of hydraulic pumps and motors can fill the bill and save you money.

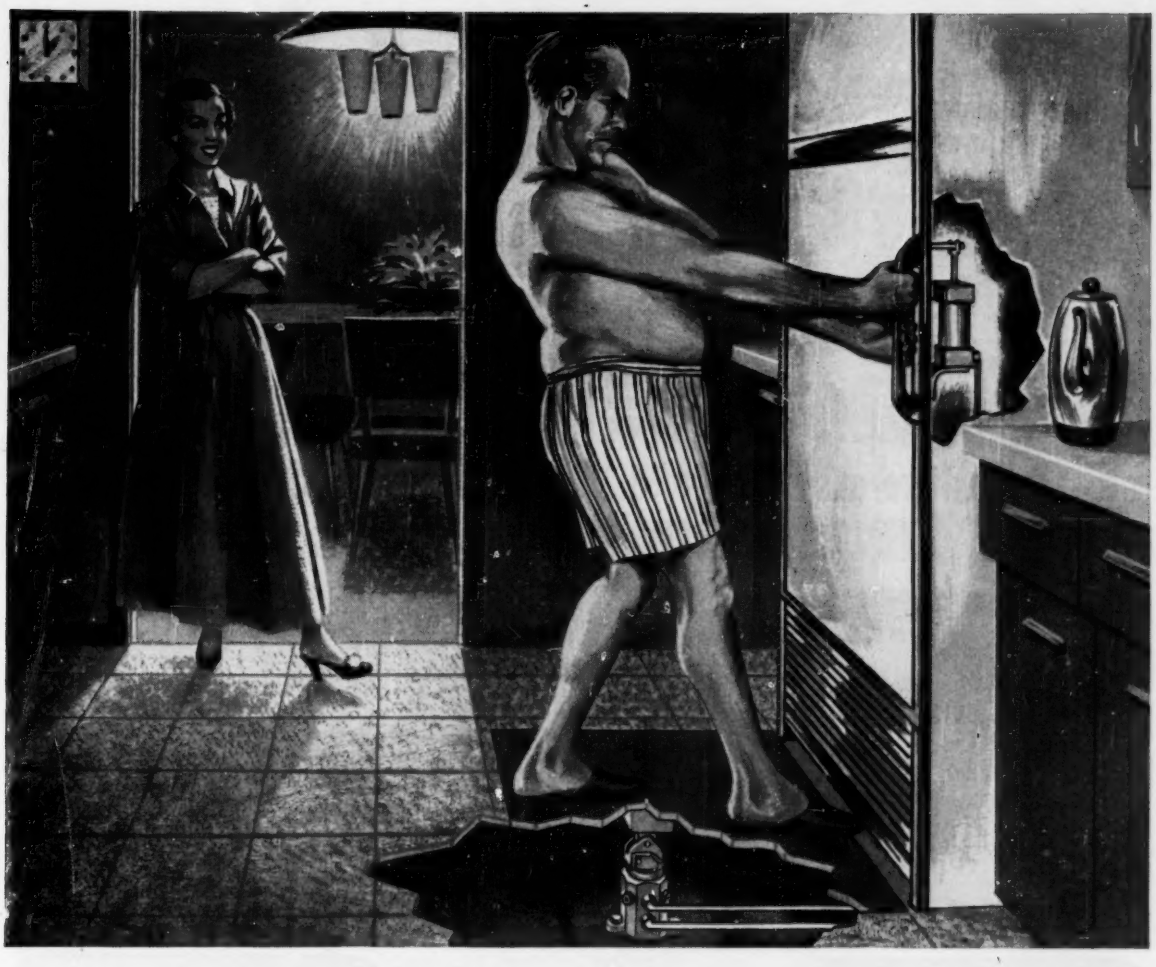
New bulletin helps you select the correct hydraulic pump or fluid motor. Detailed charts give full performance data on pump and motor combinations. Write today for your copy of Bulletin 810-M.

EASTERN INDUSTRIES ★ PUMP DIVISION ★ ®

EASTERN INDUSTRIES, INC.

100 SKIFF STREET • HAMDEN 14, CONN.

Circle 401 on Page 19



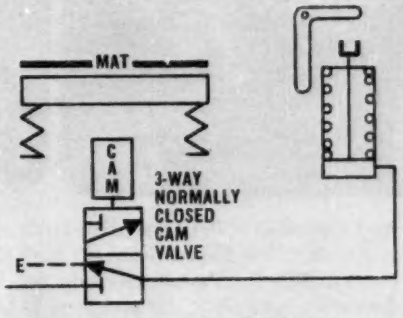
What? Air Won't Let Him Get Too Fat!

We admit we are not serious, but . . .

In a previous moment of strength he has set the controls—now, if he weighs over 200 pounds when he steps on the mat in front of the refrigerator, the door just won't open. But while he is under 200 pounds, no trouble. Now, it's highly unlikely that the refrigerator folks will be mobbed by eager buyers for such a diet-master model, but we have jumped on it as a good chance to show how a cam valve can say "yes" or "no."

Ross Cam Valves can "think" for your circuits, too

Cam valves are the key to air automation. They can act on almost any mechanical signal to set off . . . or restrict . . . another operation. Then still another cam valve can interlock that circuit with yet further operations and so on until any number of operations can be sequencing one another. Are you realizing the full possibilities from cam valves? The Ross line includes so many models, we invite you to call your Ross representative or write us.



SEQUENCE OF OPERATION

Sufficient weight on mat depresses cam, operating valve and moving cylinder to point where it restrains door handle from opening.

Ross OPERATING VALVE CO. 109 E. Golden Gate Ave. • Detroit 3, Michigan

Circle 404 on Page 19

THERE'S POSITIVELY
NOTHING LIKE NEW GOODYEAR

positive drive

BELTS

—for positive assurance of quality in maximum-efficiency belts

With Goodyear quality Positive Drive Belts now at your disposal, you're free to explore all these new avenues in machine or appliance design—

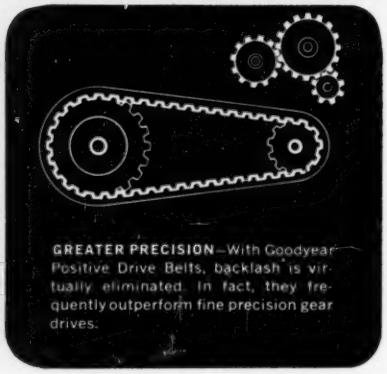
SMALLER SIZE—With Goodyear Positive Drive Belts, you can use smaller pulleys — shorter centers — narrower belts of higher capacities. Center distance can be permanently established.

LIGHTER WEIGHT — With their high horsepower-to-weight ratio, Goodyear Positive Drive Belts are ideal for portable tools, machines and aircraft assemblies. Pulleys can be light plastics or alloys.

LIGHTER BEARINGS — Since the use of Goodyear Positive Drive Belts makes high tension no longer necessary, bearing loads are much less. Some bearings as well as adjustable motor bases and idlers may be eliminated entirely.

LESS NOISE—Goodyear Positive Drive Belts assure the quietest of drives in normal speed ranges. They eliminate chatter and vibration, too.

SIMPLIFIED MAINTENANCE — Since Goodyear Positive Drive Belts involve no metal-to-metal contact, no lubricating systems, oil-retaining devices, etc., are necessary. That bars possible product contamination, too.



GREATER PRECISION—With Goodyear Positive Drive Belts, backlash is virtually eliminated. In fact, they frequently outperform fine precision gear drives.

And remember — Positive Drive Belts are designed and built to the famed Goodyear high standards of quality. For full details on belts for drives from fractional to 600 H.P.—for speeds up to 16,000 f.p.m., contact the G.T.M. — Goodyear Technical Man. He's available through your Goodyear Distributor — or by writing Goodyear, Industrial Products Division, Lincoln 2, Nebraska, or Akron 16, Ohio.

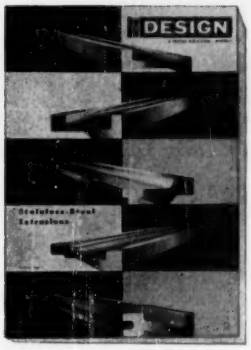
Goodyear Positive Drive Belts are manufactured under license and according to U. S. Patents 2,507,852 and 2,397,312.

POSITIVE DRIVE BELTS BY

GOODYEAR

THE GREATEST NAME IN RUBBER

Circle 405 on Page 19



Front Cover: Emphasizing the high versatility of the extrusion process, artist George Farnsworth's cover keynotes the beginning article in a two-part series on stainless-steel extrusions by Dick Paret, Page 114.

January 8, 1959

Mighty Mo 22

FRANK A. TWITCHELL and J. W. F. BLIZARD JR.—*News Report*—Molybdenum, champion at high temperatures and problem-child on the production line.

Engineers Pay: 1958 29

NEWS REPORT—Results of the comprehensive EJC survey of engineers' earnings.

Auditing Product Programs 106

PHILIP MARVIN—What to look for in setting up and maintaining a practical running inventory of the status of the company's "product portfolio."

Stainless Steel Extrusions 114

RICHARD E. PARET—*Part 1: Process Characteristics*—Advantages and limitations of the extrusion process, properties of stainless-steel extrusions, intricate shapes.

Building Light Into Instruments 118

V. A. ORLANDO and J. J. FRAIZER—How to design for optimum readability of dial markings and indicators under all possible seeing conditions.

Rubber-Base Adhesives 128

R. K. HUMKE—A primer on adhesive selection: Thermoplastic and thermosetting compositions, effects of additives on bond properties, industrial applications.

Shaft and Bearing Loads 133

M. F. SPOTTS—A simplified approach to deflection and load calculations for continuous shafts carried by three or more support bearings.

Helical and Bevel Gears 137

DONALD J. MYATT—*Data Sheet*—Equations and tables for rapidly finding approximate gear dimensions from either wear or bending limits.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

January 8, 1959

Volume 31—No. 1

Toward Management Status 105

COLIN CARMICHAEL—*Editorial*

Engineering News 6

Liquid nitrogen cools, pressurizes X-15—"poor-man's" alloy challenges stainless steel—industry team quits on advanced reactor—SAGE and Bomarc team up for supersonic kill—missile designer says space hydraulics need work—miniature pump takes direct turbine drive.

Scanning the Field for Ideas 112

Three-in-one color element—paddle-wheel drive for rotating cylinders—twisted-rod screw design for rotary-linear motion conversion.

Design in Action 124

"Broken" tracks in turnover device provide opening for transfer fingers—hydraulic cylinders swing derrick left and right—"lift truck" on overhead crane moves sidewise, up and down, forward and backward.

Tips and Techniques

Squaring numbers 111
Aluminum bar weight .. 111
Cube roots 123
Line weights 123
Sphere dimensions 136
Complex reciprocals ... 136
Dividing tip 136

Design Abstracts 141

New Parts and Materials 150

Engineering Department Equipment 184

The Engineer's Library 189

Noteworthy Patents 192

Meetings and Expositions 42

Helpful Literature 144

Subject Index 17
Reader Service Cards 19
Advertising Index 205
Business Staff 205

IN THE NEXT ISSUE: Materials test reactor . . . soft ride for heavy loads . . . measurement as a design tool . . . thermal stresses in design . . . slip clutches and brakes . . . mirror-image cams . . . the torque motor . . . four-bar linkages

Editor
COLIN CARMICHAEL

Associate Managing Editors
BENJAMIN L. HUMMEL
ROBERT L. STEDFELD

Associate Editors
LEO F. SPECTOR
ROBERT C. RODGERS
WILLIAM S. MILLER
SPENCER R. GRIFFITH

Assistant Editors
FRANCIS A. HUSARIK
CLARE E. WISE
JAMES A. PARKS
THEODORE M. LEACH
STANLEY G. COOK
JANE H. SMITH
MARIAN L. EICHAR

Art Editor
FRANK H. BURGESS

Contributing Editor
ROGER W. BOLZ

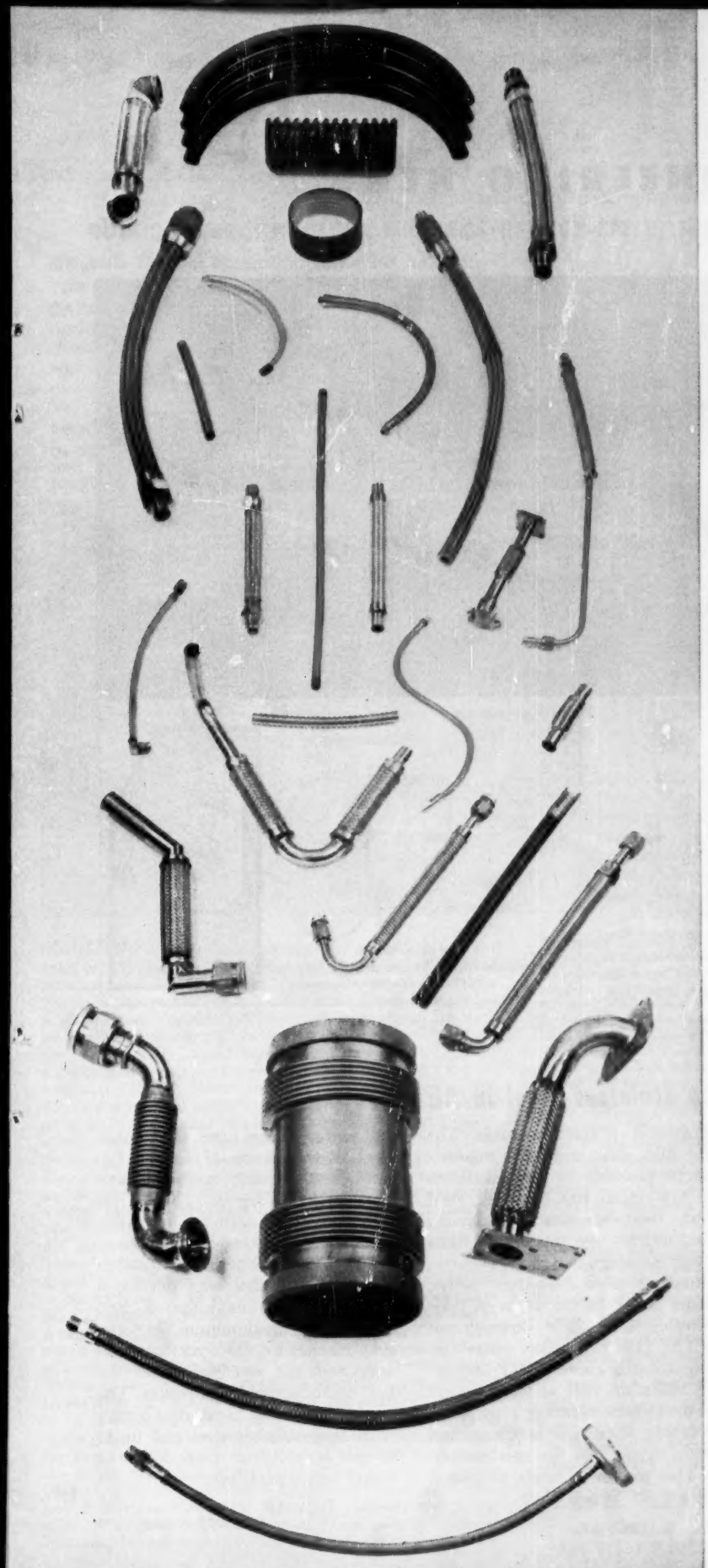
EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



TELL US WHAT THE FLEXIBLE HOSE OR CONNECTOR MUST DO

Our engineers will send you design suggestions that can save you time and money.

Jet aircraft, modern chemical plants, rockets, atomic energy plants have created a new technology that calls for new products. The American Metal Hose Division of The American Brass Company is constantly working with design engineers on special flexible assemblies to meet new problems.

American is equipped to work in:

Copper alloys
Stainless steel
Other alloy steels
Monel
Aluminum
Teflon

Anaconda specialists welcome the opportunity to help you get the flexible metal hose assemblies you need to meet your problems of expansion and contraction, movement, vibration, corrosion, pressures, and temperatures.

FREE TECHNICAL SERVICE. For engineering assistance on special products—or for a free copy of our General Catalog showing the full line of standard American Flexible Hose and Tubing products—write: The American Metal Hose Division, The American Brass Company, Waterbury 20, Connecticut.

58169

WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL HOSE AND TUBING

an

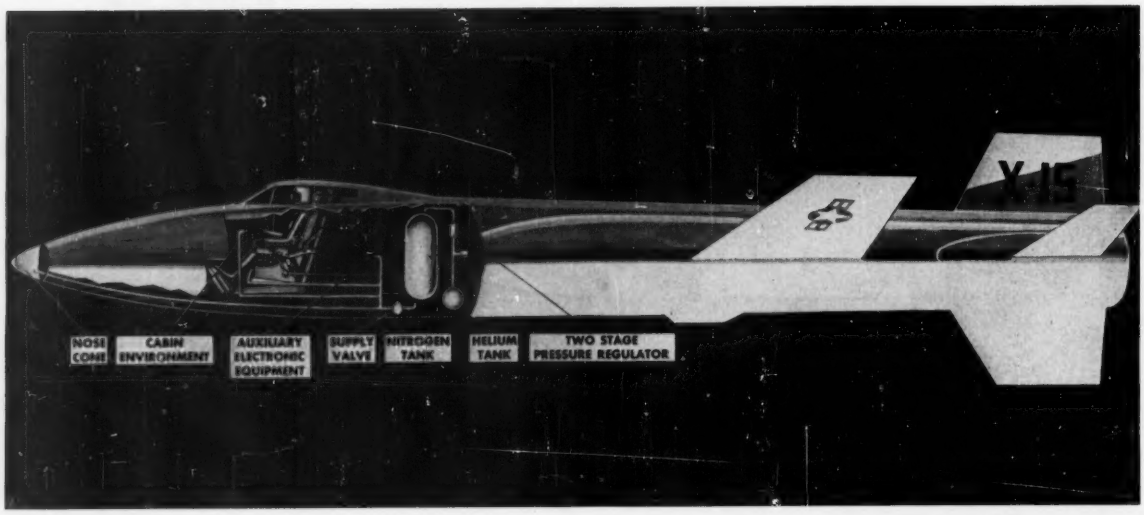
ANACONDA®

product

Made by The American Metal Hose Division, The American Brass Company

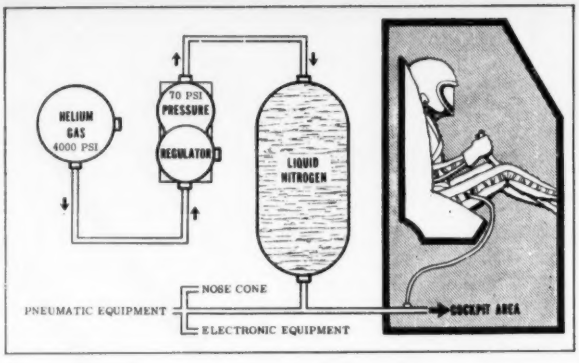
Circle 406 on Page 19

ENGINEERING NEWS



Sophisticated Atmosphere for X-15

Liquid and gaseous nitrogen will maintain environmental pressure and air-condition the pilot and equipment aboard NASA's rocket-powered X-15. The highly advanced system has the job of pressurizing and ventilating the cockpit and the pilot's flight suit, cooling and pressurizing electronic equipment and inerting its atmosphere, cooling the plane's nose cone (by liquid-nitrogen spray), and operating pneumatic equipment. Helium gas, pressurized at 4000 psi, is used to pump the liquid nitrogen and assure constant flow during high acceleration loads. The complete system was developed by AiResearch Mfg. Div., Garrett Corp., Los Angeles. It will receive first flight tests early this year.



Poor-Man's Alloy May Replace Stainless Steel in Aircraft

New Austenite Is Lighter than 18-8

CAMBRIDGE, MASS.—A new austenitic steel formed with an aluminum additive has many of stainless steel's desirable features and adds a few bonuses of its own for the user. Although further research is needed to establish optimum alloying ratios, developers are excited by the new metal's light weight, economy, oxidation resistance at high temperatures, strength at high temperatures, and age-hardening features.

Cold-working and machining difficulties will be small for fabricators accustomed to stainless steels. The same dies, rolls, and other machinery can probably be used, although the new metal has a higher yield point than stainless. Machining characteristics are much like those of type 304 stainless.

Previous aluminum-iron alloys, besides being brittle at room temperature, lost their strength at 1200 F. The new alloy series has good strength above 1200 F and resists oxidation well at temperatures up to 1500 F. Heating after work hardening increases hardness and tensile strength of the new material. This treatment tends to anneal and soften many types of stainless steel. Extrapolation of known figures for austenitic steel indicates that strengths up to 250,000 psi may be reached with the new alloy through strain aging by heating.

Navy and National Research Corp. metallurgists who developed the alloy have found that a ratio of 10 per cent aluminum, 34.4 per cent manganese, 0.76 per cent carbon, and the rest iron gives the best combination of properties. The resultant metal is 15 per cent lighter than 18-8 stainless steel and up to 25 per cent lighter than cobalt or nickel base superalloys.

Circle 407 on page 19→

. . . Fluid Power news

REPORT No. 11,703 NEW SPEED FOR SHIP'S FREIGHT ELEVATORS

From Oilgear Application-Engineering* Files

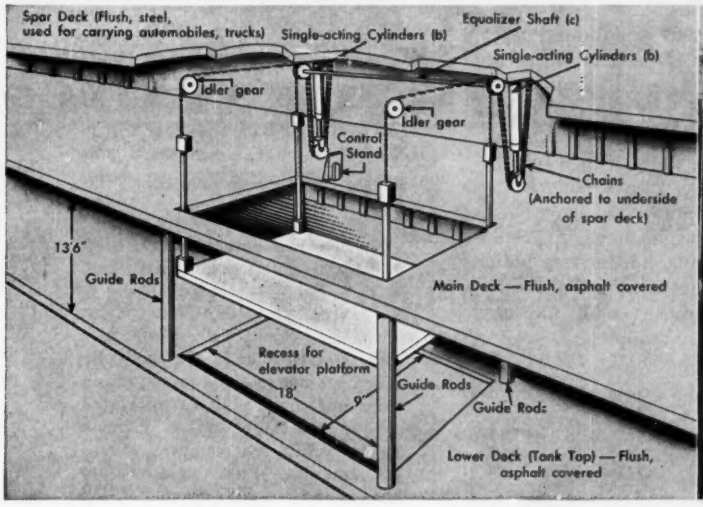
HOW OILGEAR Æ* SOLVED PROBLEMS OF HIGH-SPEED, SHIPBOARD FREIGHT ELEVATORS

OWNER: Canada Steamship Lines Limited

(Builder — Collingwood Shipyards, Division of Canadian Shipbuilding & Engineering Limited)

DATA: Oilgear was employed on a consulting basis to decide which of two experimental hydraulic systems should replace slow, untidy, steam, shipboard freight elevators. (Both systems were found to have serious power, control, or installation problems.)

REQUIREMENTS: 1: Power and control for four elevators in each of two new 460-ft. ships — the S.S. Fort Henry, and S.S. Fort York . . . the first new Great Lakes package freighters to be built in over 25 years. Both ships will be required to maintain fast, tight schedules with palletized freight or bulk grain. 2: A 16-second max. time for the 13½-ft lift-lower cycle with a 10-ton load. 3: Be completely "fail-safe" in event of power failure. 4: Platforms must have four-way, drive-on, drive-off lift truck accessibility — eliminating counterweight systems. 5: Systems must be leak-tight and have provisions for complete "sealing-off" when grain is carried. 6: Must be thrifty with electrical power, as all four elevators operate simultaneously — a heavy load on the ship's power generating system.



SOLUTION: A new Oilgear power and control system for each of four elevators per ship that surpasses all original requirements . . . has many "Patent Pending" features. For each elevator there is an Oilgear "Power-Pak" using a size DH-60, variable displacement, two-way pump with hydraulic servo control, an electric motor, mounted on a semi-hermetically sealed reservoir. "Down cycle" power regeneration is an outstanding feature that provides exceptional electric power economy. In regeneration, the downward load on cylinder fluid drives the Oilgear pump as a motor — driving the electric motor, reducing electrical power input. This system could regenerate ALL of the energy stored in the elevator platform and payload, if the ship's electrical system could absorb the feedback from the electric motors. As the generating system cannot stand a high degree of electrical feedback, an Oilgear regeneration limitation control valve is installed to closely limit the amount of regeneration practical to use during the "down" cycle of the elevators. Other features are: 1: Speed of operation — lift-lower cycle averages 14 seconds . . . an increase of 10 complete work cycles per hour more than originally specified . . . 100 tons per hour increase in possible payload at normal elevator capacity. 2: A continuous, automatic, self-leveling system that keeps platform at deck level regardless of load changes. 3: Automatic "fail-safe" system that holds the platform in position if power fails. 4: Single lever speed and direction control. 5: A leak-tight, trouble-free, dependable system in a "grain-tight" housing. Oilgear's business is the engineering and building of the finest, complete systems supplying the power for — and the control of any linear or rotary motion. Oilgear *Application-Engineered Controlled Motion Systems* are simplest to install, operate, and maintain — they're a complete system for a specific application — with one responsibility for that entire system.

Breakaway drawing shows Oilgear Controlled Motion elevator system operating between main and lower decks. Fluid Power from Oilgear "Power-Pak" is piped to two single-acting cylinders (b) mounted vertically from the underside of the spar deck. Controlled Fluid Power forces rams down, bringing elevators up through a simple chain-pulley system. Equalizer shaft (c) keeps elevator platform level at all times. Photo above illustrates the complete ease of unloading platform with two lift trucks operating from opposite sides. During normal loading or unloading operations, 14 or more lift trucks and truck-trains are used to keep pace with the 4 elevators. Photo — right — taken from elevator platform 'tween decks shows operator at the control stand. Continuous, automatic, self-leveling interlock can be seen at arrow (d). Chain-pulley system and equalizer shaft (c) are also clearly visible to side and top.

Other Oilgear marine applications include power and control systems for steering and flanking gear, catapults, hoists, winches, large valve controls, lock and dam gates.

. . . for the lowest cost per year — it's Oilgear!

For similar practical solutions to YOUR rotary or linear drive and control problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

Industry Team Calls Quits on Homogeneous-Reactor Program

Westinghouse, Utility Say Prototype Cost Too High

WASHINGTON—An economic reef of the atom age—the high cost of advanced-reactor prototypes—scuttled an ambitious nuclear-power project at the tail end of 1958. Pennsylvania Power and Light Co. and Westinghouse have told AEC that they've abandoned efforts to build an aqueous homogeneous reactor.

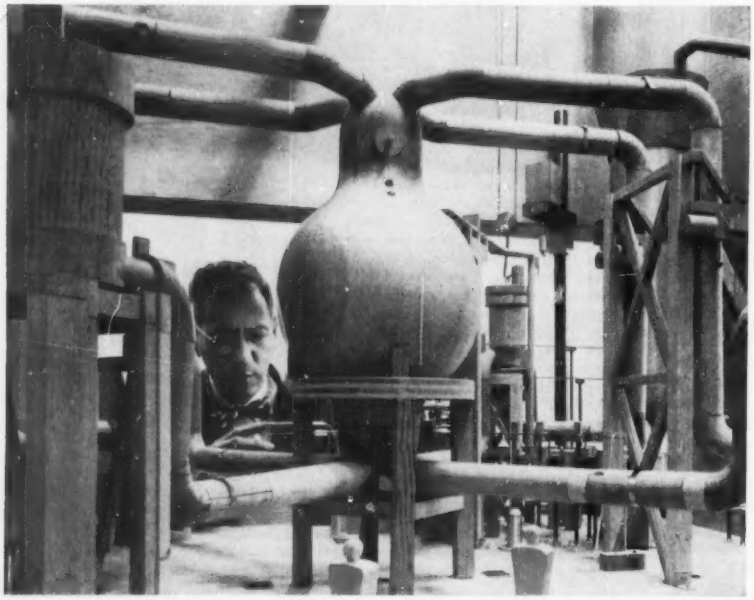
Reasons were both technical and financial: After spending $8 million and three years, the co-operating companies said they can no longer justify the mounting research and development costs without first building and operating a large-scale prototype.

Begun by P. P. & L. and Westinghouse in 1955 as an advanced concept with important long-term promise, the homogeneous reactor was accepted for contract negotiation in 1958 under AEC's Power Demonstration Reactor Program. The type was selected because of its low fuel cost, continuous fuel reprocessing possibilities, and ability to create new fissionable fuel.

Under the proposed AEC contract, a decision based on research results would have been made near the end of 1959 on whether to construct the plant or discontinue the project. Total estimated cost to the co-operating companies and the Commission would have been $108 million.

Cancellation of the venture sharpened up lines dividing proponents of public and private development of advanced-reactor cycles. Sen. Clinton Anderson, Vice Chairman, Joint Committee on Atomic Energy, said he was "not surprised" at the announcement.

"As a matter of national policy, I believe it is undesirable to permit the field of advanced atomic power to be 'staked out' as the private domain of industry," said Sen. Anderson. He put forth a controversial plan: "I have endorsed an expanded atomic-power program in which AEC would develop the advanced concepts, and private industry would sponsor 'second and third' generation projects with increased Government assistance."



Simple in concept, the homogeneous reactor offers a number of unique problems. This wood and plastic model, built by Westinghouse's atomic power department, helped designers study remote-handling procedures and equipment-placement problems. In the center is the reactor vessel. Connected to it are four primary loops which carry a slurry of thorium and uranium-oxide fuel suspended in heavy water, which serves as moderator and coolant. Slurry is circulated by pumps through the reactor vessel, where the nuclear reaction takes place, and then out to steam generators.

Topics

A very little light on the subject, provided by a new "jelly-bean size" flash bulb, will permit taking flash pictures with a miniature camera. General Electric has developed a bulb 1⅛ in. long and about as big around as a pencil, with light output equal to a more expensive bulb four times as large. To go with the new lamp, GE has designed a reflector only 2 in. in diameter. The company foresees a flashholder in which the small bulbs would be advanced like film by means of a lever.

• • •

Slugs and snails may be what space men's diets will be made of. On long flights, during which algae supply oxygen and food, these intermediate algae-eating "delicacies" could provide protein in a more familiar and desirable form, according to Dr. Robert G. Tischer, bacteriologist at Mississippi State University. It is felt that on a two and a half or three-year trip to Mars, for instance, a crew would grow tired of eating algae cake and chemical porridges.

• • •

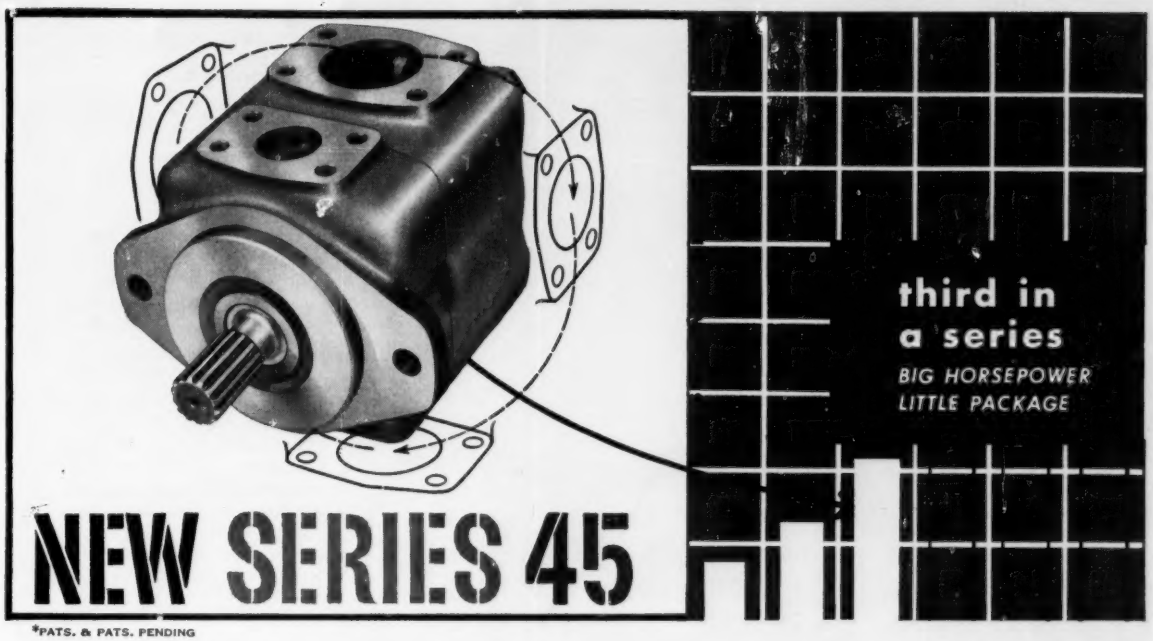
Negative ions have a positive effect on persons suffering from hay fever, asthma, and sinusitis. Researchers at the Lamp Div. of Westinghouse, Bloomfield, N. J., are experimenting with ultraviolet lamps that will produce quantities of ions in the air. It was found that charging the air with positive ions caused fatigue, dizziness, and headaches, and aggravated asthma and sinusitis. Where negative ions were in the air, such symptoms were relieved, and wounds healed more rapidly.

• • •

No angle is divided into three parts without measuring—so says the National Bureau of Standards, which occasionally receives a letter from someone who claims to have trisected an angle. The Bureau answers such claims with the reminder that leading mathematicians agree it can't be done if one respects Plato's restrictions limiting the use of compass and ruler to drawing circles and lines.

• • •

A machine to replace mother has been constructed by the staff of the University of Wisconsin's primate laboratory to study "human" love and effects of parental emotions on offspring. Baby monkeys reared by the "mother machine" will never be scolded, spanked, or subjected to normal parents' impatience or anger. Reported to be affectionately accepted by baby monkeys, the machine provides nourishment, warmth from an internal electric lamp, and the cuddliness of a foam rubber and terry cloth body.



*PATS. & PATS. PENDING

VICKERS® "high performance" vane pump

• high speed • high pressure • high efficiency • high service life

NEW COMPACT DESIGN . . . much more horsepower than previous pumps of the same package size.

NEW VANE CONSTRUCTION . . . positive vane tracking at all operating speeds assures efficient operation at increased speeds and pressures.

NEW SIZES not previously available . . . answers mobile equipment designers' need for greater hydraulic horsepower in limited space.

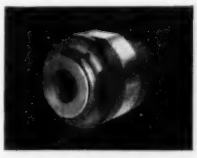
NEW PARTS INTERCHANGEABILITY . . . many common parts for single and double pumps (two pumps on the same shaft in one envelope). Lessens inventory requirements.

NEW 4-BOLT SAE FLANGE CONNECTIONS . . . will also accommodate user's 2-bolt flanges of the proper design.

NEW 2-BOLT MOUNTING (SAE 1959 STD.).

NEW 4-POSITION COVER . . . outlet can be rotated in 90° increments with respect to inlet.

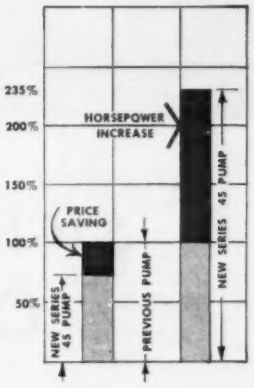
NEW REPLACEABLE PUMPING CARTRIDGE . . . all wearing parts of pump are incorporated in one replaceable cartridge. Easy field replacement without removing pump from its mount. Cartridges available in kit form.



MUCH MORE HORSEPOWER PER DOLLAR

The striking increase in horsepower per dollar of the Series 45 over previous pumps of the same delivery capacity is shown in the graph to the right. Maximum horsepower is more than double (235%) and price is lower by 35%.

This is the third unit released in the new complete line of "High Performance" Pumps, single and double. The first (Series 25) is available in 12, 14 and 17 gpm sizes and the second (Series 35) comes in 21, 25 and 30 gpm sizes (at SAE rating of 1200 rpm and 100 psi). This new Series 45 pump is available in 35, 42 and 50 gpm sizes.



The table below shows characteristics

Model Number	Delivery—gpm		Input Horsepower @ 2000 rpm 2000 psi	Package Size†	Weight
	1200 rpm 100 psi	2000 rpm 2000 psi			
2V35A-1*10	34	52	71	L. 7¾" W. 6¼" H. 6½"	69 Lbs.
2V42A-1*10	41	63	86		
2V50A-4*10	48	75	103		

†Exclusive of Shaft Extension and Mounting Lobes

8201

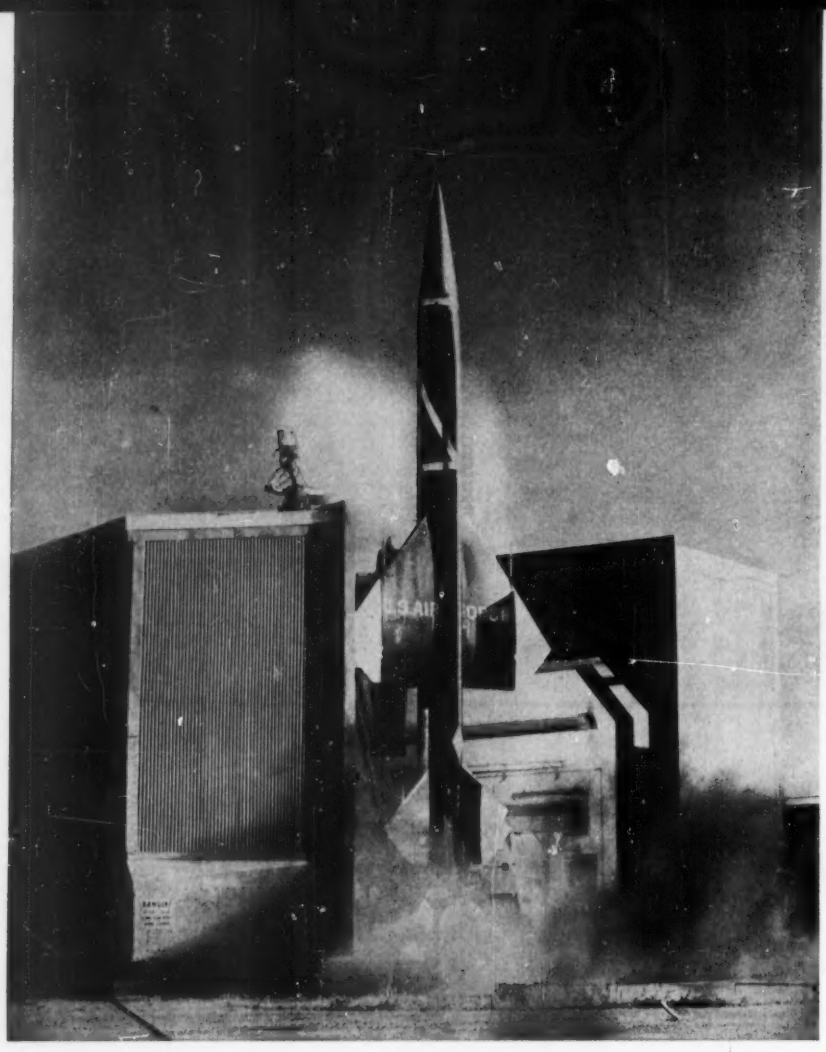
Write for new illustrated Bulletin No. M5108 for further details and performance characteristics.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Springfield, N.J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • SAN FRANCISCO AREA (Berkeley) SEATTLE • ST. LOUIS • TULSA
ALSO SOLD AND SERVICED IN AUSTRALIA, ENGLAND, GERMANY & JAPAN
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto, Montreal & Vancouver

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 408 on Page 19



Triggered from a SAGE control center nearly 1500 mi away, a Bomarc ground-to-air missile blasts off to intercept an "enemy" aircraft approaching the Florida Coast. The missile is computer controlled from the ground for most of its flight until its own terminal guidance system locks on the target. SAGE then tips the missile into a dive, and Bomarc makes a kill.

SAGE-Bomarc

Computer/Killer Team

SAGE (Semi-Automatic Ground Environment), the nation's vast, coordinated air-defense system, will soon be completely operational. Its job: To detect, track, intercept, and kill any enemy missiles or aircraft approaching continental U. S. In the event of attack, SAGE will not only control the launching and guidance of anticraft missiles and jet interceptors, but will even decide which missiles and/or aircraft to use.

Heart of the SAGE system is a special computer, built by International Business Machines Corp., that digests all radar contacts, military and commercial flight plans, and weather conditions in its particular air-defense sector. The computer automatically calculates for the air commander the most effective employment of his defensive weapons.

In recent tests, an IBM/SAGE computer at Kingston, N. Y., has fired and controlled Bomarc missiles at Cape Canaveral—1500 mi away. When the SAGE-Bomarc systems become fully integrated, missiles will be controlled from the nearest SAGE installation, but the procedure will be similar.

During typical tests, hostile aircraft are detected off the Florida coast by radar installations located near Cape Canaveral. Range and bearing are transmitted 1500 mi, via leased lines, to Kingston for input to the SAGE computer. The target then appears on the computer scope, just as it does on radar.

On the basis of the target's range, heading, and altitude, the speed and flight characteristics of Bomarc, and on the basis of atmospheric conditions in the target area, the computer determines an "engagement prediction point." The computer operator then presses a

N/D CASE HISTORIES

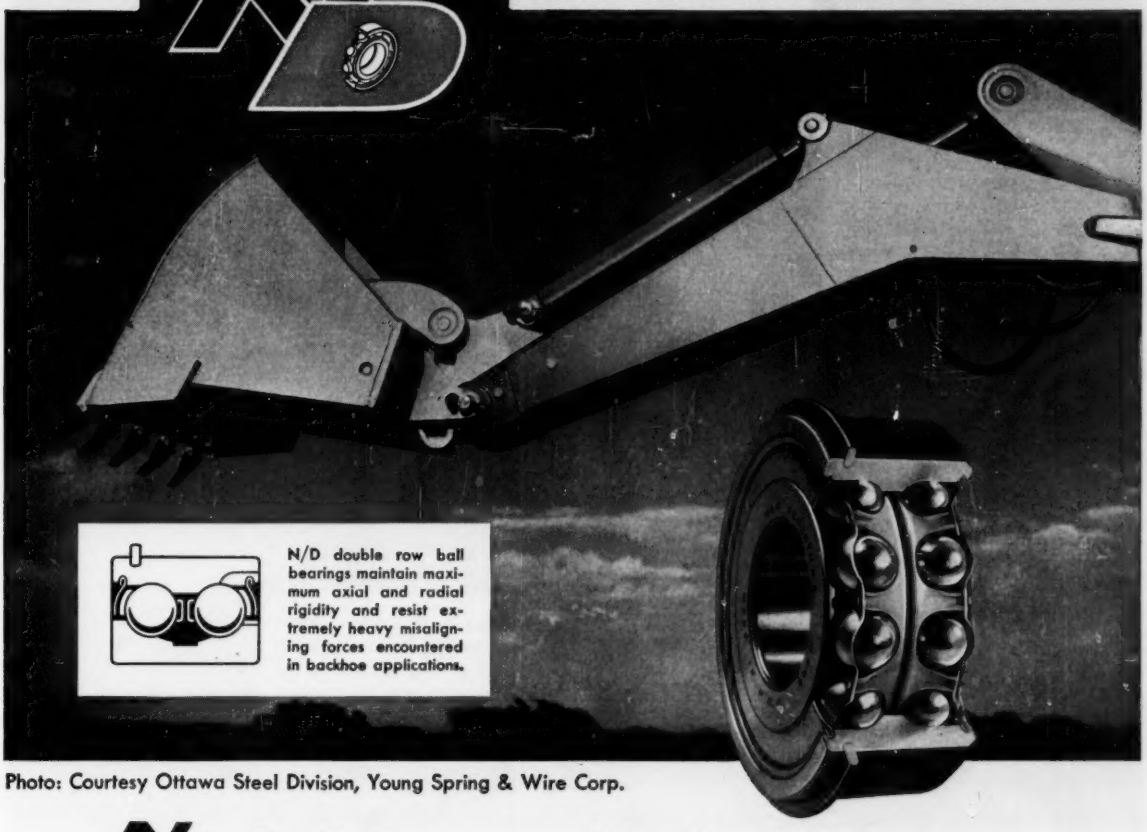

N/D double row ball bearings maintain maximum axial and radial rigidity and resist extremely heavy misaligning forces encountered in backhoe applications.

Photo: Courtesy Ottawa Steel Division, Young Spring & Wire Corp.

N/D Ball Bearings Reduce Friction... Up Usable Hydraulic Power In Backhoe!

CUSTOMER PROBLEM:

Increase efficiency of tractor/truck-mounted backhoe and reduce in-the-field maintenance requirements for the end customer.

SOLUTION:

N/D Sales Engineer, working with the manufacturer, recommended replacing 10 bronze bushings with factory lubricated New Departure shielded ball bearings. These New Departures eliminated arm play and loose joints . . . reduced friction to make more, useful hydraulic power available! What's more, shielded N/D ball bearings resist wear. They eliminated the need for relubrication maintenance because they're lubricated for life!

If you're working on new equipment designs, or redesigning, why not call on New Departure? New Departure's wide selection of construction and farm equipment ball bearings means there's probably a production bearing that will help you. For more information, write Department Q-1.

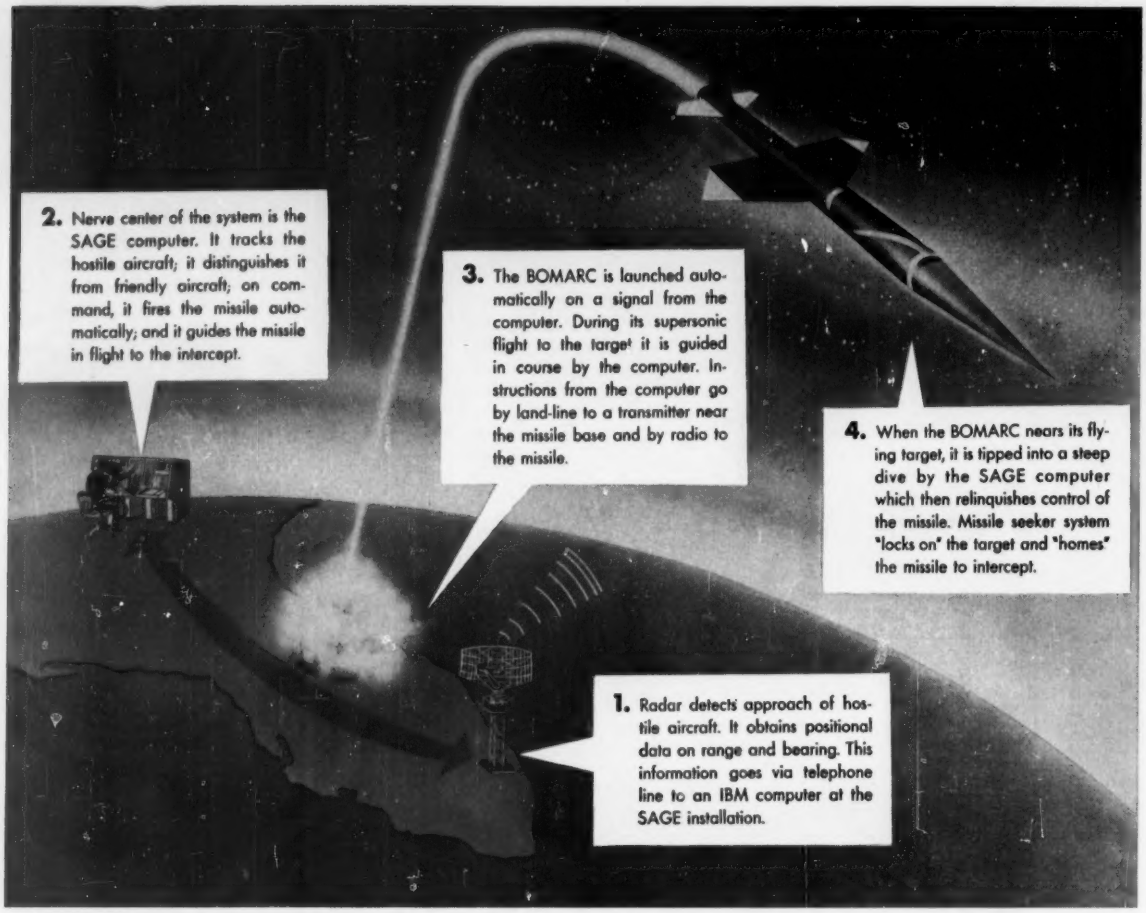
Available through United Motors System and its Independent Bearing Distributors.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Circle 409 on Page 19


2. Nerve center of the system is the SAGE computer. It tracks the hostile aircraft; it distinguishes it from friendly aircraft; on command, it fires the missile automatically; and it guides the missile in flight to the intercept.
3. The BOMARC is launched automatically on a signal from the computer. During its supersonic flight to the target it is guided in course by the computer. Instructions from the computer go by land-line to a transmitter near the missile base and by radio to the missile.
4. When the BOMARC nears its flying target, it is tipped into a steep dive by the SAGE computer which then relinquishes control of the missile. Missile seeker system "locks on" the target and "homes" the missile to intercept.
1. Radar detects approach of hostile aircraft. It obtains positional data on range and bearing. This information goes via telephone line to an IBM computer at the SAGE installation.

Each SAGE control center is capable of controlling a number of Bomarc missiles in simultaneous flight against a number of tracked targets. The system will also accommodate other types of missiles and jet interceptors. Piloted jets are guided to target by directions radioed from the SAGE computer to automatic pilots in the planes.

firing button, and Bomarc blasts off from the Florida coast.

While Bomarc heads for the target, the computer at Kingston begins tracking both the target and the missile. For every maneuver made by the target, the computer instantly calculates a new heading for the missile. This information is relayed to Cape Canaveral, and radioed from there to the Bomarc.

Bomarc continues its flight under computer guidance until it begins a supersonic dive on the target. At this point, the computer relinquishes control, and the missile's own terminal guidance system takes over for the kill.

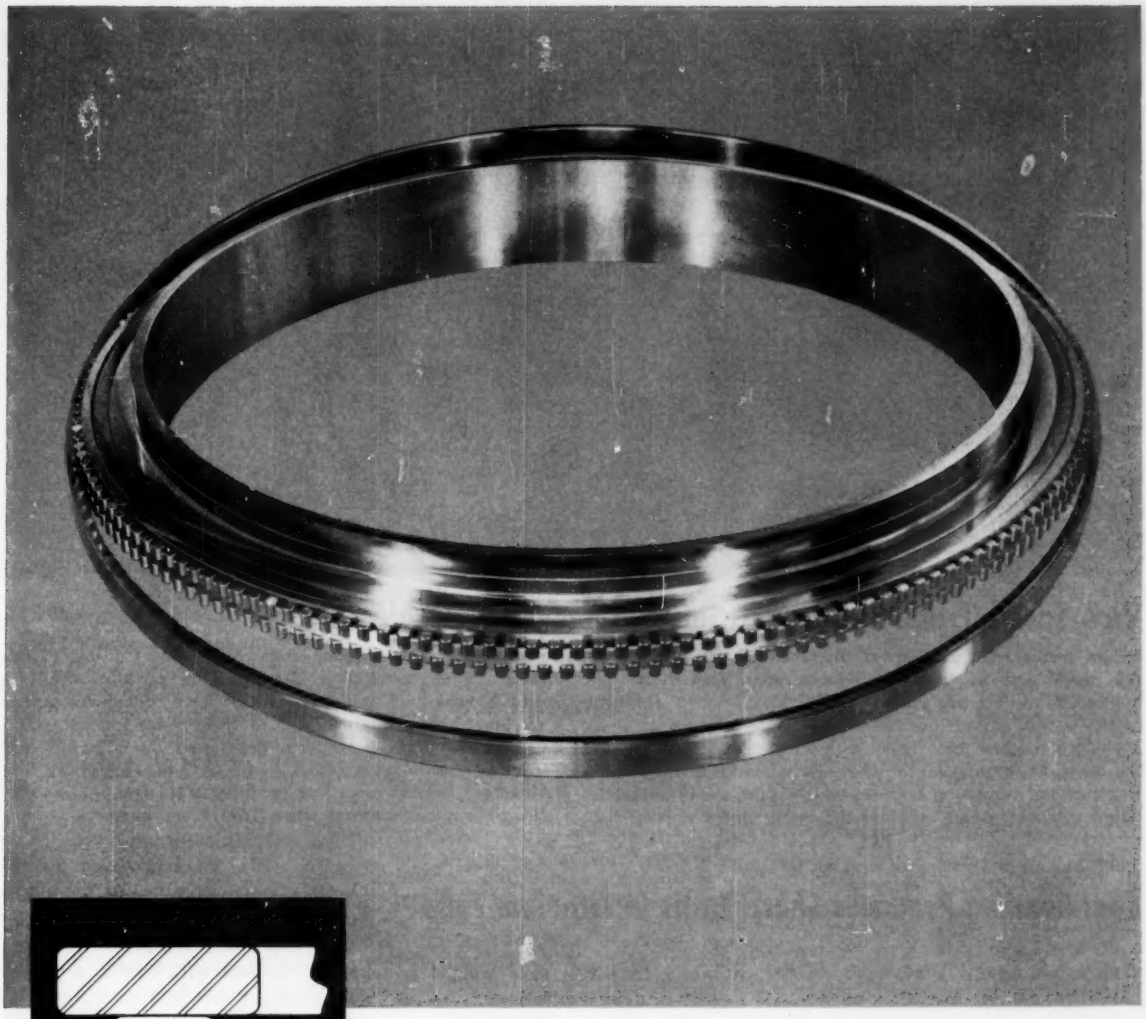
Dark Age in Coming Century Predicted by Scientist

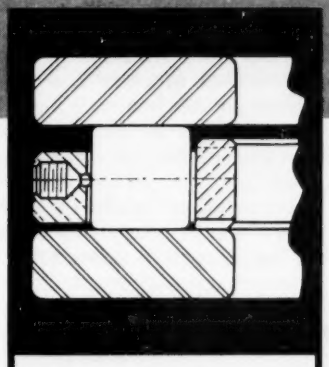
Man's Peak Scientific Efforts Will be Followed by Lull

ANN ARBOR, MICH.—After a peak in scientific creativity, coming sometime around 1973, mankind's creative efforts will gradually diminish until a low of scientific achievement is reached somewhere around 2055 AD. This is the opinion of Dr. Stewart West, a University of Michigan scientist who studies historical cycles of creativity. Figures on scientific activity dating back as far as 600 AD show that such a peak comes about every 164 years, he explains. West concedes that data for this type of prediction are sparse, but cites corroborating evidence:

- Analysis of membership trends in American Physical Society shows fastest growth will come just after 1973.
- 1980 will mark approximate end of creative life for scientists trained about 1940 when "team research" was first being developed.
- Population forecasts for 20 western nations show a new period of stability in mid 21st century.

West believes creativity cycles are closely related to population growth. He doubts that knowledge of these cycles will enable men to control them. However he points out that Russian science, which is part of western science, will be subject to the same trend. ". . . Russia and the U. S. appear to be converging toward the same type of culture—from widely separated points, of course," he stated.





Running mate of the Torrington Radial Roller Bearing pictured is this Torrington Cylindrical Roller Thrust Bearing 52 in. OD, assembled face runout 0.0004 in., capacity 222,000 pounds at 100 rpm.

A picture of precision... 57.500 inches in diameter!

Here is an ultra-precision Torrington Radial Roller Bearing, custom-built for Wickes Machine Tool Division's 48" Center Drive Profile Lathe.

Almost five feet (57.500 in.) in diameter, it has a total inner race runout of only 0.0005 in. Its 344 rollers are held uniform in diameter within 0.00005 in. Radial capacity is 318,000 lb. at 100 rpm. Rollers are staggered in a one-piece, fully machined bronze cage for precise guidance and cool running. The bearing bore is tapered one inch per foot, and carefully mated to the spindle which was also ground by Torrington.

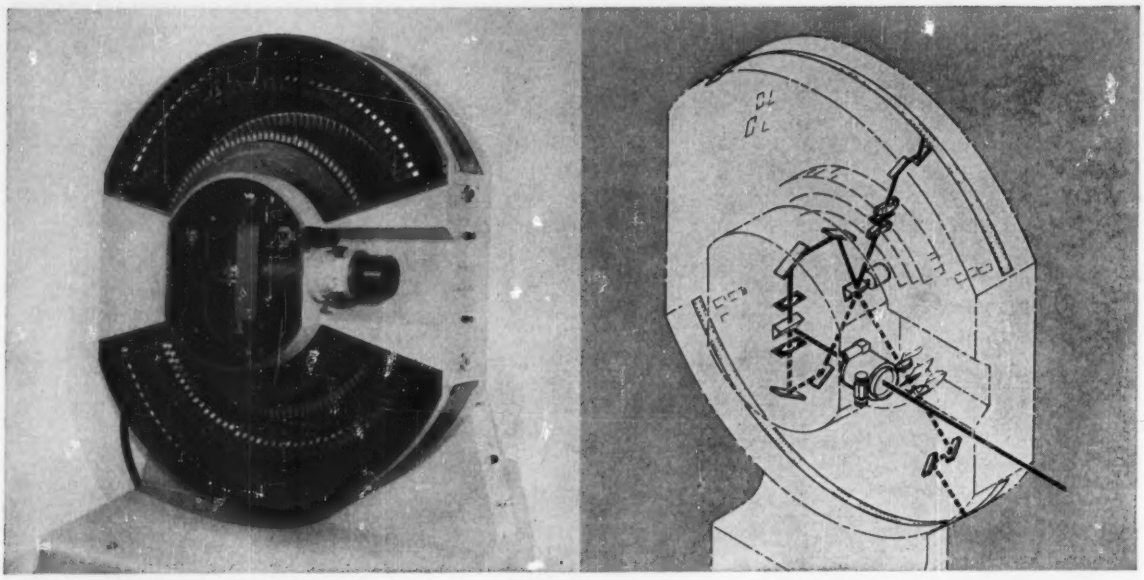
Such precision is possible only through specialized equipment and highly practiced skills—the same that lie behind the quality of every Torrington bearing, standard or special. Not every bearing order calls for such precision—but each is given the extra measure of care that makes Torrington quality a byword in industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on Page 19



High-Speed Framing Camera Solves Blind-Spot Problem

Image traces that overlap at the ends of two opposing film tracks can be joined without a blind spot in a 1.5 million frame per sec continuous-writing camera. Design of the optical system guarantees a complete record of any event (55 mu sec total time) regardless of the position of the camera's rotating mirror when the sequence is triggered. Heart of the camera is a prism which splits the unresolved beam into two paths. Before the upper beam finishes its sweep, the lower beam begins scanning the lower film strip. After developing, the matching parts of the two films can be overlapped and cut at some convenient frame, the remainder being spliced to give a continuous record of the event. The camera, developed by Beckman and Whitley, San Carlos, Calif., will be especially useful in situations where an event is difficult to synchronize with the high-speed rotating mirror.

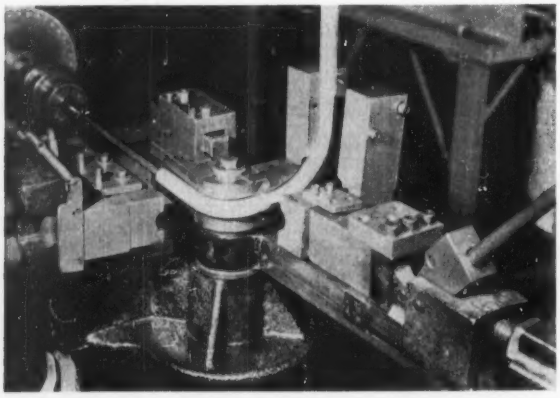
Cool Bending Produces Sharp Turns in Titanium Tube

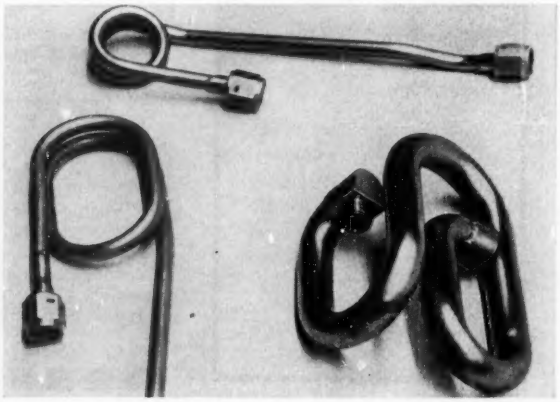
Research Opens Way For Missile, Jet-Aircraft Use

PATERSON, N. J.—Titanium tubing can now be bent safely on a radius as small as its own inside diameter. Kreisler Industrial Corp., Paterson, N. J., is producing tube shapes of titanium that will save weight on rockets and jet aircraft and, at the same time, provide significant corrosion resistance.

Although the tubes are formed cold, no annealing or stress relief are necessary for most finished products. A special mandrel, teamed with a clamp fitted with jaws that conform to the shape of the tube, does the job. With the piece securely locked in place, clamp and mandrel are slowly rotated until the required angle is formed. Speed and pressure can be closely controlled.

Kreisler has co-operated with Superior Tube Company, Norristown, Pa., suppliers of titanium tube, in





Jig containing a rotatable mandrel and clamp can be swiveled at a controlled rate to make wrinkle-free, sharp bends in titanium tube. Complicated multidirectional turns are possible, and sharpness of bends compares favorably with conventional results on more ductile tubing, such as stainless steel and aluminum alloys.

working out the following suggestions to designers specifying titanium tubing:

- Specify soft, A-40 grade titanium tubing.
- Provide maximum possible wall thickness.
- Whenever possible select bend radii at least three times O.D. of the tubing.
- Specify equal, uniform radii for all bends in a series.
- Provide generous lengths of metal between bends and other formed sections.

Shotgun Technique Solves Complex Problems Quickly

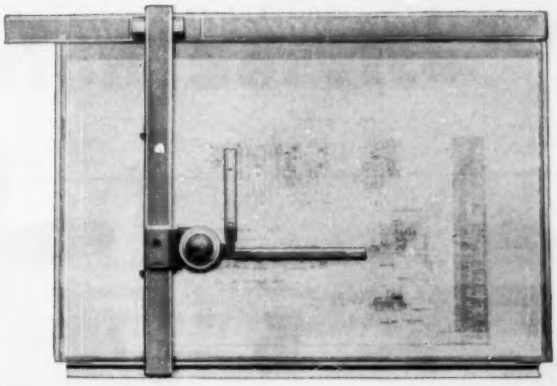
Chemical Society Advocates Polyvariable Experimentation

BOSTON—Put as many variables as possible into your experiments to get the most for your research dollar. That is the essence of the philosophy behind a new experimental technique developed and proposed by Dr. F. E. Satterthwaite and used already by several industries with problems too complex for classical analysis.

In contrast to the usual laboratory approach, where one variable at a time is isolated and examined while others are held as nearly constant as possible, the new technique, called random balance, juggles ten or more variables in a series of random experiments. Value levels of the variables to be considered are carefully chosen before experiments are run, and results from a satisfactory number of tests are tabulated. Statistical methods isolate the roles of the important variables—often variables that would have been dismissed as unimportant by classical methods.

At an all-day conference of the Northeastern Section of the American Chemical Society, Inc., where the technique was presented, conferees were reminded that natural progress through evolution is a form of polyvariable analysis. "How effective is evolution?" asks Dr. Satterthwaite and Dorian Shainin in a conference paper. The answer: "It is effective enough to develop man."

DRAFTING TRENDS



The Universal Tracmaster drafting machine, currently being introduced by POST, is perfectly balanced for all board angles without protruding counterweights. The Tracmaster features extreme parallel accuracy, offering featherlight responses for easy operation, with the same overarm protractor head used on the famed Universal Boardmaster drafting machine.

Advance information about outstanding new track drafting machine

Over recent years, drafting techniques have progressed to machines and boards designed for variable angle drawing . . . from near-horizontal to high angle vertical positions. There has been a growing need for more efficient tables to minimize draftsmen's fatigue . . . for drafting equipment suitable for long traversing and large layout drawings . . . as well as for drafting machines suitable for ultra-precise detail work.

Now POST brings you the most advanced track drafting machine yet developed. It's the Universal Tracmaster . . . a perfectly balanced X-Y track drafter with unvarying parallel accuracy from one end of the board to the other. The Tracmaster glides smoothly and easily, horizontally and vertically, with precise accuracy of angle and dimension at *any* board angle. All of this is accomplished without use of counterweight attachments of any kind.

An outstanding *exclusive* feature of the Tracmaster is the inclusion of track graduation, *in addition* to all the usual angular and dimensional measurements. On each track, numbered graduations are provided at precise 10-inch intervals —for quick, easy reckoning. In effect, these graduations divide the entire drawing area into a 10-inch grid pattern—useful for establishing reference points or measuring and drawing long lines—with no cumulative error due to repeated scale extensions.

The extremely rigid horizontal beam rail you see across the top of the Tracmaster is mounted to the board by two brackets. Once mounted, there is *never* a need for adjustment. The machined beams *always* stay straight.

Efficient design conserves space

If space is a problem, you'll find the Tracmaster a perfect answer. There are *no* protruding arms or weights in the back, so the machine can be used close to walls or near other tables. You can actually put more tables in a given area using the Tracmaster on a Hamilton Auto Shift or L-Angle Table than you can with any other drafting combination. In fact, in all POST's years of experience in working to serve draftsmen, engineers and designers, this combination of the Universal Tracmaster with modern Hamilton equipment offers by far the best opportunity to materially improve drafting efficiency.

The Tracmaster's protractor head is the same as the protractor used on the famous Universal Boardmaster drafting machine. It provides full 360° visibility; has a powerful, positive and full circle baseline setting; and a ball bearing indexing head. With this protractor head you quickly, conveniently and accurately lock your scales to any position.

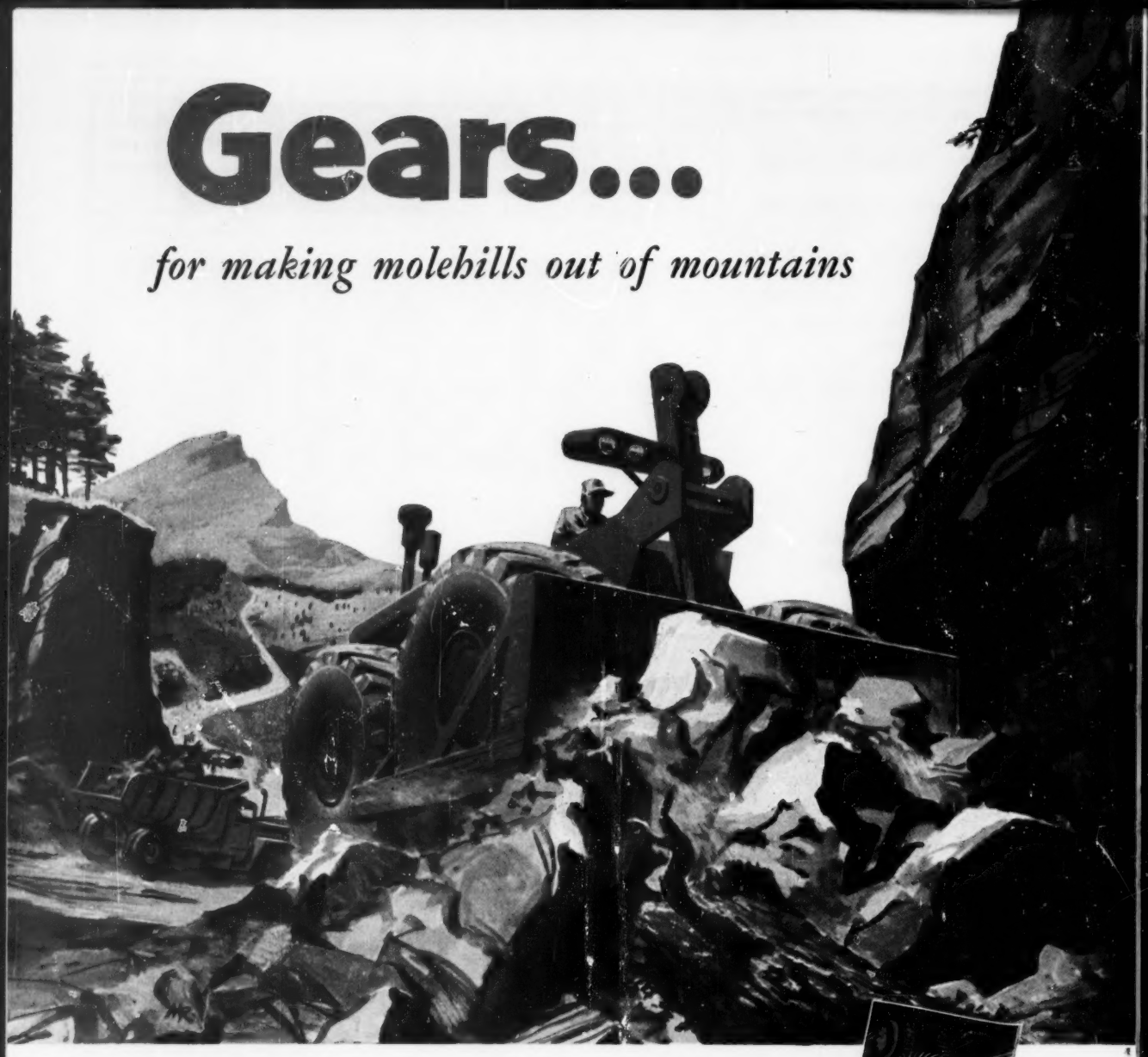
For more information on the Tracmaster drafting machine, write today to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

Gears...

for making molehills out of mountains



It is hard to imagine worse working conditions, and that is the very reason why the manufacturers of so many kinds of road building equipment install "Double Diamond" gears. Wherever the going is especially rough, wherever gears must give uninterrupted service on harsh, time-table schedules, you'll find our gears at work.

For low installed cost, for true operating economy and performance, and for buckling down to the hardest kind of service—nothing beats "Double Diamond."

Our salesmen are experienced gear engineers. Why not talk to one about your gear requirements?

May we send you a copy of this comprehensive catalog on the many gear types in which we specialize?

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 412 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Actuators, Edit. 113
Adhesives, Edit. 30, 128, 142
Aluminum and alloys, Edit. 141, 142

Balls, Adv. 198
Bearing materials, Adv. 63, 147
Bearings, Edit. 133
  ball, Edit. 178; Adv. 11, 13, 48, 83, 146, 164, 197
  miniature, Adv. 146, 164
  needle, Adv. 13
  rod-end, Adv. 166
  roller, Adv. 13, 90
  sleeve, Adv. 63, 147, 155
  support, Edit. 133
  thrust, Adv. 13
Bellows, Adv. 203
Belts, transmission, Edit. 180; Adv. 2, 42, 43
Blowers, Edit. 164, 169; Adv. 71, 199
Books, Edit. 189; Adv. 180, 182, 184, 186, 190, 200, 202, 207
Boosters, air, Edit. 178
Brakes, Adv. 185
Brass (see Copper and alloys)
Bronze (see Copper and alloys)
Bushings, Adv. 63, 147, 155
  ball, Adv. 147

Carbides, Adv. 54
Carbon and graphite parts, Adv. 101
Castings, die, Adv. 163, 182
  high alloy, Adv. 54
  iron, Adv. 54
  light alloy, Adv. 163, 182
  malleable iron, Adv. 60, 88, 89
  sand, Adv. 60
  shell-molded, Adv. 60, 167
  steel, Adv. 54, 60
Chain, transmission, Adv. 46, 156, 169
Clad metals, Adv. 62
Classified ads, Adv. 188, 204, 206
Clutches, Edit. 113, 192, 194; Adv. 46, 58, 146, 151, 185, 192
Coatings (see also Finishes)
Coatings, protective, Edit. 142, 150; Adv. 179
Cold heading, Adv. 170
Connectors, electric, Edit. 152, 161; Adv. 196
Contacts, Edit. 182
Control systems, electric, Adv. 170, 174, 183
  hydraulic, Adv. 7, 174
  mechanical, Adv. 174
  pneumatic, Adv. 86, 174
Controls, electric, Edit. 112, 141, 155, 164, 165, 169, 182; Adv. 65, 74, 91, 143, 159, 161, 166, 168, 174, 183, 199, 200, back cover
  hydraulic, Edit. 32
  mechanical, Adv. 181, 197
  pneumatic, Adv. 40, 86, 157
Copper and alloys, Adv. 72, 155
Couplings, fluid, Adv. 5, 69, 70, 198, 201
  shaft, Edit. 150; Adv. 46, 152, 192
Cylinders, hydraulic, Edit. 126, 156; Adv. 33, 69, 70, 93, 97
  pneumatic, Adv. 33, 40, 86, 93, 97, 157, 196

Drafting equipment, Edit. 184, 187; Adv. 15, 56, 177, 184, 203
Drives, adjustable speed, Edit. 158, 168; Adv. 76, 161, 199
Ducts, Edit. 150

Electric equipment (see specific type)
Engineering department (see Management or Drafting)
Engineers' pay: 1958, Edit. 29
Extrusion, Edit. 114; Adv. 161

Fans, Adv. 71
Fasteners, bolts, nuts, screws, Edit. 156, 162, 166; Adv. 21, 34, 64, 100, 104, 149, 160, 182, 195, 198, 201, 202
  locking, Adv. 21, 64, 68, 198
  pin, Adv. 21, 68
  retaining rings, Adv. 79
  rivet, Adv. 32
Filters, Adv. 31, 63, 86, 99
Finishes (see also Coatings)
Finishes, protective, Adv. 179
Fittings, pipe, tube, and hose, Adv. 5, 69, 70, 168, 198, 201
Forgings, Adv. 44, 54, 72, 92
Friction materials, Adv. 101

Gages, pressure, etc. (see also Instruments), Adv. 172
Gears, Edit. 137, 176, 184; Adv. 16, 27, 35, 41, 162, 192, 202
Gravity, Edit. 37

Handles, Adv. 200
Heat exchangers, Adv. 85
Heating, Adv. 196
Heat-resistant alloys, Adv. 54, 78
Heaters, Adv. 152
Hose, metallic, Adv. 5
  nonmetallic, Adv. 69, 70, 203
Hydraulic equipment (see specific type)
Hydraulic fluids, Adv. 75

Instruments, Edit. 118; Adv. 172
Insulation, Edit. 141, 142
Insulators, Edit. 166
Inverters, Edit. 172

Lighting, Edit. 118
Limit stops, Edit. 150
Lubricants, Adv. 101
Lubrication equipment, Adv. 86, 99, 176, inside back cover
Lubrication systems, Adv. inside back cover

Machines (see specific type)
Magnesium and alloys, Edit. 142, 180
Management, engineering, Edit. 29
Materials handling equipment, Edit. 127
Meetings, Edit. 42
Metals (see specific type)
Molybdenum, Edit. 22
Motors, electric:
  fractional and integral hp, Edit. 141, 174; Adv. inside front cover, 38, 66, 76, 96, 154, 166, 174, 189, 203
  gearmotors, Adv. 57, 192
  torque motors, Edit. 165
Motors, hydraulic, Edit. 170
Mufflers, Edit. 150

Noise rating, Edit. 142

Packings, Adv. 37, 87
Pillow blocks, Edit. 178; Adv. 48
Piston rings, Adv. 53

MACHINE DESIGN is indexed in Industrial & Engineering Index Service, both available in libraries, generally

Plastics, Edit. 155; Adv. 161, 167, 168
Plastics molding, Adv. 148, 167, 182
Pneumatic equipment (see specific type)
Powder metallurgy, Adv. 163
Pressure elements, Edit. 158
Processing equipment, Edit. 124; Adv. 148
Product programs, Edit. 106
Pulleys (see also Sheaves), Edit. 180; Adv. 36, 171
Pushbuttons, Edit. 164
Pumps, hydraulic, Edit. 37; Adv. inside front cover, 178

Reactors, Edit. 35
Reducers, speed, Edit. 174; Adv. 46, 57, 192
Regulators, flow, Adv. 86
pressure, Edit. 176, 178; Adv. 199
Relays, Edit. 155, 182; Adv. 65, 143, 159, 168, 183, 200
Resistors, Adv. 183
Rheostats, Adv. 183
Rotary joints, Adv. 201
Rubber, Edit. 142; Adv. 2, 168, 193, 197, 203
Rubber molding, Adv. 168, 197

Seals, Adv. 37, 53, 82, 84, 87
mechanical, Adv. 37
Shaft loads, Edit. 133
Shafts, flexible, Adv. 181
Shapes, special, Adv. 182
Sheaves (see also Pulleys), Edit. 180; Adv. 36, 171
Slip rings, Adv. 204
Small parts, Adv. 170, 182
Solar cells, Edit. 162
Solenoids, Edit. 168; Adv. 157
Springs, Edit. 192; Adv. 203
Sprockets, Adv. 41, 156, 169
Stampings, Adv. 175, 203
Starters, motor, Adv. 91
Steel, Edit. 142; Adv. 28, 59, 80, 92, 94, 103, 158, 165, 187
stainless, Edit. 114, 141, 142; Adv. 49, 98, 173, 187, 191
strip, Adv. 49
Switches, Edit. 165, 169; Adv. 196

Tantalum, Edit. 34
Terminals, Adv. 196
Thermocouples, Adv. 201
Timers, Edit. 155; Adv. 74, 96, 143, 200, back cover
Tips and techniques, Edit. 111, 123, 136
Titanium and alloys, Adv. 80
Transistors, Edit. 172
Transmissions, adjustable speed, Adv. 199
Tubing, Adv. 5, 72, 94, 98, 153, 168, 191, 203, 208

Universal joints, Adv. 152

Valves, hydraulic, Edit. 152, 161, 170; Adv. 33, 194
pneumatic, Edit. 170; Adv. 1, 33, 86, 145, 157, 194, 196

Welding, Adv. 102
Wire and wire products, Adv. 203

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 144

	ITEM NUMBER		ITEM NUMBER
Gas Turbines	601	Solenoid Control Valve	619
Electromagnetic Bin Vibrators	602	Explosionproof Equipment	620
Aircraft Ducting Products	603	Zinc-Plated Steel Sheets	621
Valve Flanges	604	Way Bearings	622
Temperature Control	605	Electric Pushbuttons	623
Steel & Aluminum	606	Compression Packings	624
Circuit Breakers	607	Aircraft Locknut	625
Heat Exchangers	608	Spraying Systems	626
Thermostats	609	Air Control Equipment	627
Flowmeter	610	Valve Operated Cylinder	628
Submersible Motors	611	Retaining Rings	629
Transistors	612	Potentiometers	630
Solenoid Valve	613	Servo Components	631
Carbon-Graphite	614	Industrial Controls	632
Steel Bars	615	Precision Components	633
Flexible Teflon Hose	616	Hastelloy Alloys	634
Gearing	617	Air & Gas Filters	635
Centrifugal Castings	618		

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 150

	ITEM NUMBER		ITEM NUMBER
Tiny Mufflers	636	High-Strength Insulator	658
Miniature Limit Stop	637	Adjustable-Speed Drives	659
Right-Angle Strip	638	Miniature Solenoid	660
Heat-Resistant Paint	639	Transistor Chopper	661
Miniature Shaft Couplings	640	Blower Units	662
Hydraulic Valve	641	Fluid Motors	663
Panel Receptacle	642	DC Solenoid-Operated Valves	664
Time-Delay Relay	643	Silicon Transistors	665
Epoxy Compounds	644	Transistorized Inverters	666
Panel Fastener	645	Encapsulated Motor	667
Wiping Unit	646	Speed Reducers	668
Pressure Elements	647	Precision Gear Heads	669
Adjustable-Speed Drive	648	Pressure Controls	670
Relief Valve	649	Pillow Blocks	671
Miniature Terminal Boards	650	Automatic Air Booster	672
Self-Tapping Screw	651	Magnesium Sheet Alloy	673
Silicon Solar Cells	652	V-Belt Drives	674
Miniature Blowers	653	Contact Poles	675
Single-Element Pushbuttons	654	Moment-of-Inertia Kits	676
Torque Motor	655	Speed-Changer Kit	677
Limit Switch	656	Adding-Subtracting Machine	678
Structural Panel Fastener	657	All-Steel File	679

MACHINE DESIGN
JAN. 8, 1959

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Mar. 8, 1959

MACHINE DESIGN
JAN. 8, 1959

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Mar. 8, 1959

MACHINE DESIGN
JAN. 8, 1959

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Mar. 8, 1959

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

ALLEN HEX-SOCKET SCREWS HEAD

HERE'S ALLEN TODAY!

These precision products have made ALLEN the number 1 name in the socket screw field!

Leader Point Cap Screw | Button Head Cap Screw | Flat Head Cap Screw

Allenut | Allenpoint Set Screw | "Tru-Round" Pipe Plug

Allen Shoulder Screw | Allen Hex Key | "Tru-Ground" Dowel Pin

If hex-socket screws have any place in your life at all, our new plant at Bloomfield, Connecticut, has unlimited advantages for you.—If you're an engineer or designer, for example, the modern facilities of this new plant make available to you greatly increased engineering and metallurgical services in the development of dependable fastening for products you're designing—and higher standards of precision than ever before. If you're a manufacturer, this new plant is bound to be a rich source for new ideas in fastening, and new products that will make your own products better. If you are a distributor, this new plant means prompter shipments—and both new products for your customers and improvements in existing ones, all coming along rapidly now that we have the room we need and new equipment.

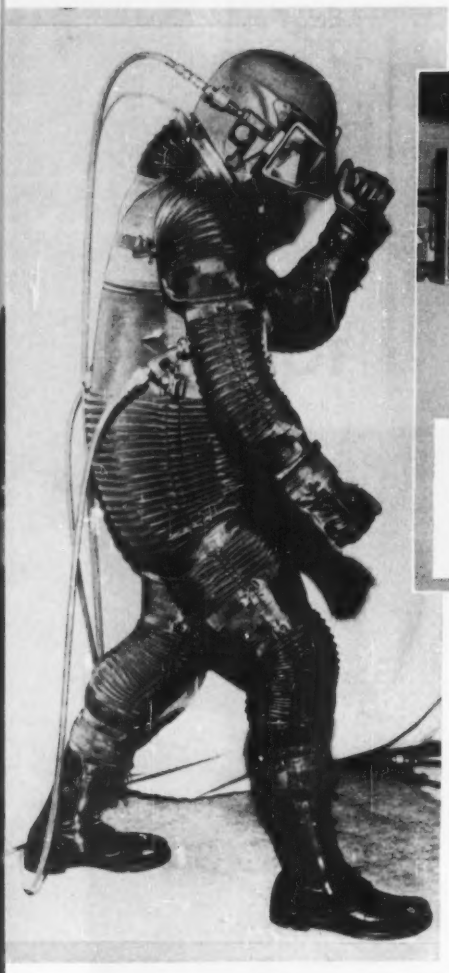
Write today for our new picture-booklet that takes you on a "guided tour" of this modern new plant.

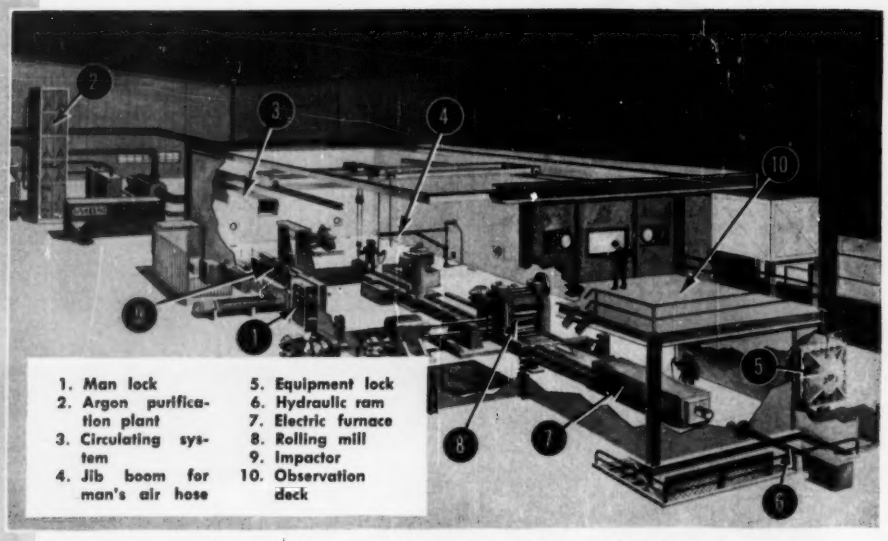
ALLEN MANUFACTURING COMPANY

Hartford 1, Connecticut

Plant at Bloomfield, Connecticut • Warehouses at Chicago and Los Angeles

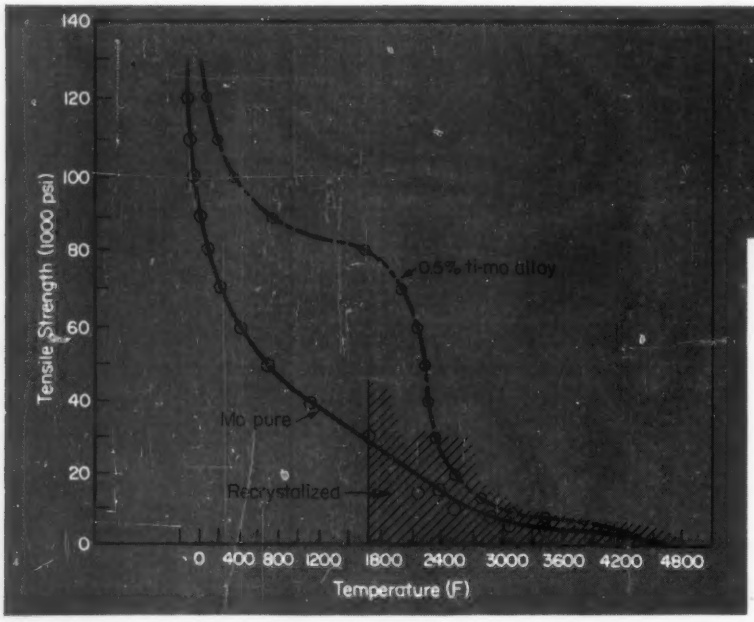
Circle 413 on Page 19





Illustration, courtesy Air Products Inc., Allentown, Pa.

Space-suited workers will handle reactive metals like molybdenum in the oxygen-free atmosphere of this metal-processing plant. Universal Cyclops Steel Corp. will put the plant into operation next year at Bridgeville, Pa. The argon-gas atmosphere is kept an ounce over atmospheric pressure to stop contamination from outside air through seepage or undiscovered leaks. Workers' "space suits" will be connected to an oxygen manifold, and elaborate precautions will be taken to protect both workers and material from contact with the wrong atmosphere. Conventional locks with two gas sealing ports receive and discharge material. An unusual personnel lock is fitted with plastic diaphragms which conform to a man's body as he passes through. This lock does not have to be "pumped down."



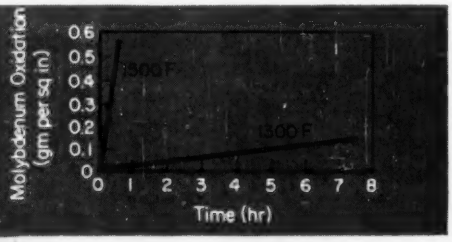
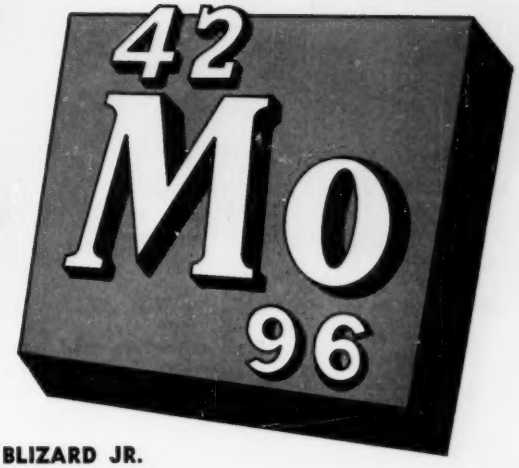


Chart (left) shows tensile strength vs. temperature for molybdenum-titanium alloy and pure molybdenum. Recrystallization range has been shaded. Plot above shows oxidation in gm per sq in. vs. time of exposure of unprotected molybdenum at temperatures in the range needed for normal working.

Growing importance of high-temperature structures leads designers to eye the advantages, combat the drawbacks of

mighty



By FRANK A. TWITCHELL and **J. W. F. BLIZARD JR.**
Senior Production Design Engineer — Production Design Engineer

Northrop Div. Northrop Aircraft Inc.
Hawthorne, Calif.

ONLY TEN METALS remain solid above 3500 F. The most abundant is molybdenum (Mo). Researchers seeking materials to withstand temperatures expected in future air and space vehicles are studying molybdenum as a likely candidate. Already in use for megatron components, stirrers in glass furnaces, and resistance-wire contacts, its use at high-temperatures depends only on the possibility of protecting it from oxygen.

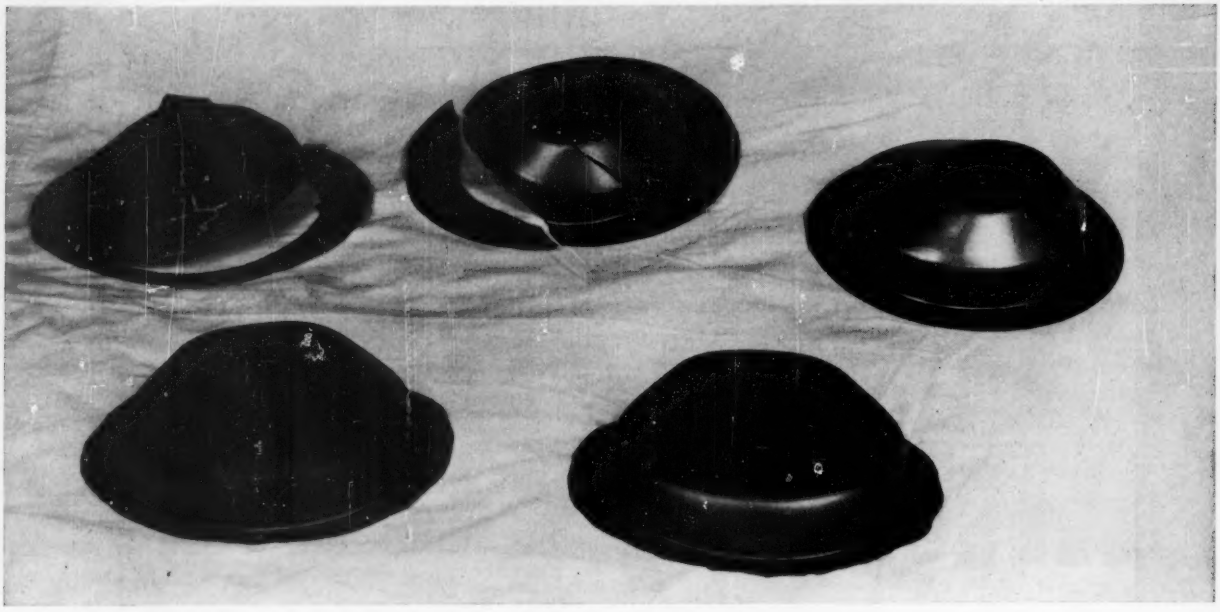
Molybdenum has two noteworthy weaknesses—extreme brittleness at room temperature and rapid oxidation at high temperatures. An inert-atmosphere plant now being built will minimize these difficulties during fabrication. The designer who finds application for the special characteristics of Mo can live with its shortcomings.

Sintered molybdenum ingots, made by powder metallurgy, are available in weights from 7 to 500 lb. Density of these ingots approaches a theoretical maximum of 10.22 gm per cc. Vacuum arc cast ingots can be obtained in sizes up to 1000 lb.

Overcome Brittleness With Heat

Operations such as forming, upsetting, forging, extrusion, and spinning have been successfully accomplished with molybdenum. Forming must be done at temperatures between 400 F and 1200 F. Severe forming operations require tempera-

Designs now on the boards for space craft, ultrasonic aircraft, and nuclear reactors will call for refractory metals that remain solid above 3500 F. Of these, molybdenum is the most plentiful. Ninety per cent of the world's supply of molybdenum comes from the U.S. It may be the metal of the future if two problems—brittleness and oxygen affinity—can be met.



Disastrous effects of drop-hammer forming at temperatures that are too low are clearly shown in this part of a jet-engine combustion chamber. A severely formed part such as this should remain near 1200 F during the forming cycle.

tures of at least 1200 F which must be maintained during the forming cycle.

If full recrystallization is allowed during forming, it results in a low-strength material with poor room-temperature ductility. Therefore, heating above recrystallization is used for the fabrication of parts only if mechanical properties are important, or if subsequent processing will produce necessary properties.

Very little springback has been noticed in molybdenum forming, so heat sizing is not required. Grain direction control has proved an important factor in forming operations and should be specified by designers. Drop-hammer forming can be accomplished without heated tooling, provided that quick transfer from the furnace to the tool and one-hit stage dies are utilized. Heated tooling is required in all cases where metal contact will chill the material below minimum forming temperatures.

Molybdenum can be successfully forged at temperatures from 1800 F to 2400 F. At these temperatures, the oxide formed (causing a material loss of 3 to 5 per cent) serves as a good lubricant. The forming of molybdenum by extrusion of arc-cast ingots has been done directly by the Ugine Sejournet Process. Worked powder metallurgy billets have also been extruded to produce tubes. Spinning can be accomplished conventionally provided the temperature of the molybdenum sheet is maintained over 400 F. Tools of aluminum bronze or other materials of low friction coefficient must be employed.

Designers: Keep an Eye on the Cut

It is possible to mill, turn, drill, or counterbore molybdenum by taking proper precautions. It tends to flake or chip off on the side toward which the feed is progressing near the end of a cut; it has an abrasive action on cutting tools, making necessary frequent sharpening, and the necessity for meticulous chip removal; it is easily contaminated by sulphur base oils; and it requires closely controlled cutting speeds to assure optimum results.

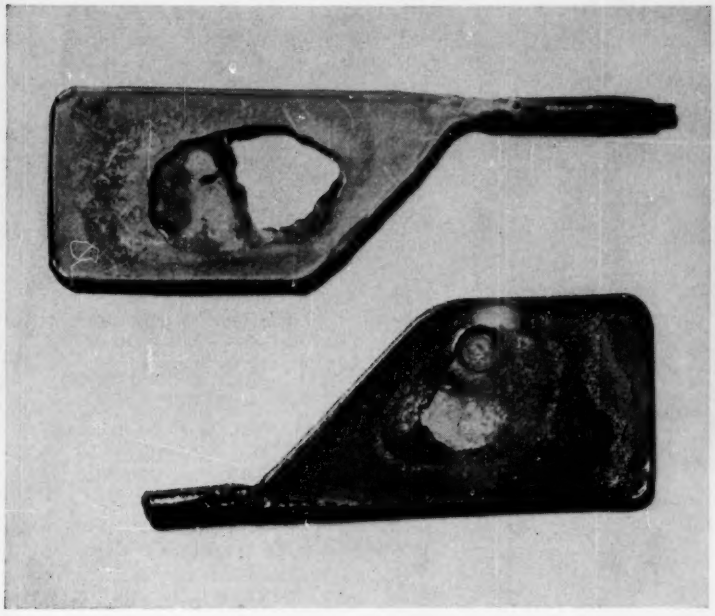
To avoid these difficulties, designers who specify molybdenum should, where it is their responsibility, specify firm clamping and backing during machining to prevent vibration and chatter; specify chlorinated cutting oils, which seem not to contaminate molybdenum as badly as sulphur-based oils; and avoid parts requiring shaping operations where molybdenum might chip at the end of a cut. Sawing may be done with a fine-toothed blade at high speeds if the saw generates enough heat directly ahead of the blade to avoid cracking. However, for sheets under 0.05 in. thick, shearing at a temperature of 400 F is a better specification.

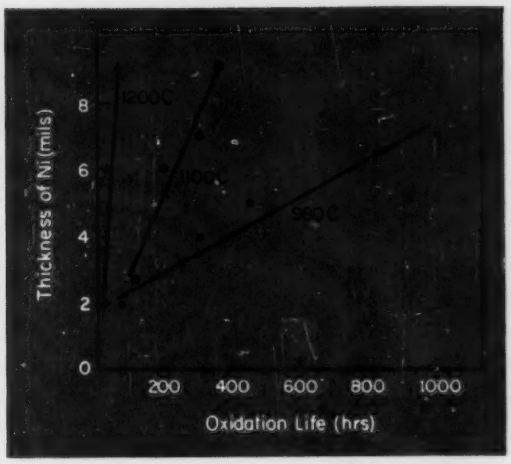
Like Glass— Handle With Care!

The in-plant handling of molybdenum parts and material at room temperature is one of the most critical operations in the fabrication of this material. A completely new approach stressing extreme care will be necessary to eliminate fractures produced by mishandling. It has been suggested that molybdenum should be handled like glass when cold and like metal at temperatures over 400 F.

How to Specify a Joint

Molybdenum has been successfully joined by spot welding, arc



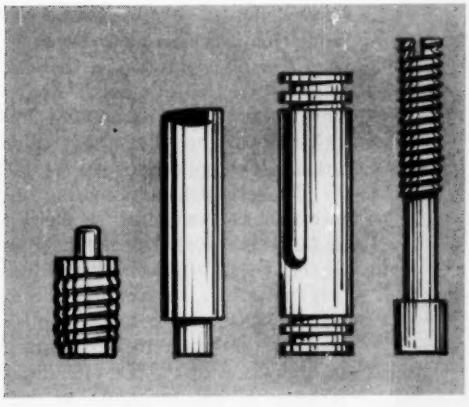


Destructive action on molybdenum of extremely high temperatures is blocked by chrome-nickel plating. Samples shown survived 300 hrs at 1100 C before holes were burned through. Graph demonstrates that unprotected molybdenum disintegrates in a short time.

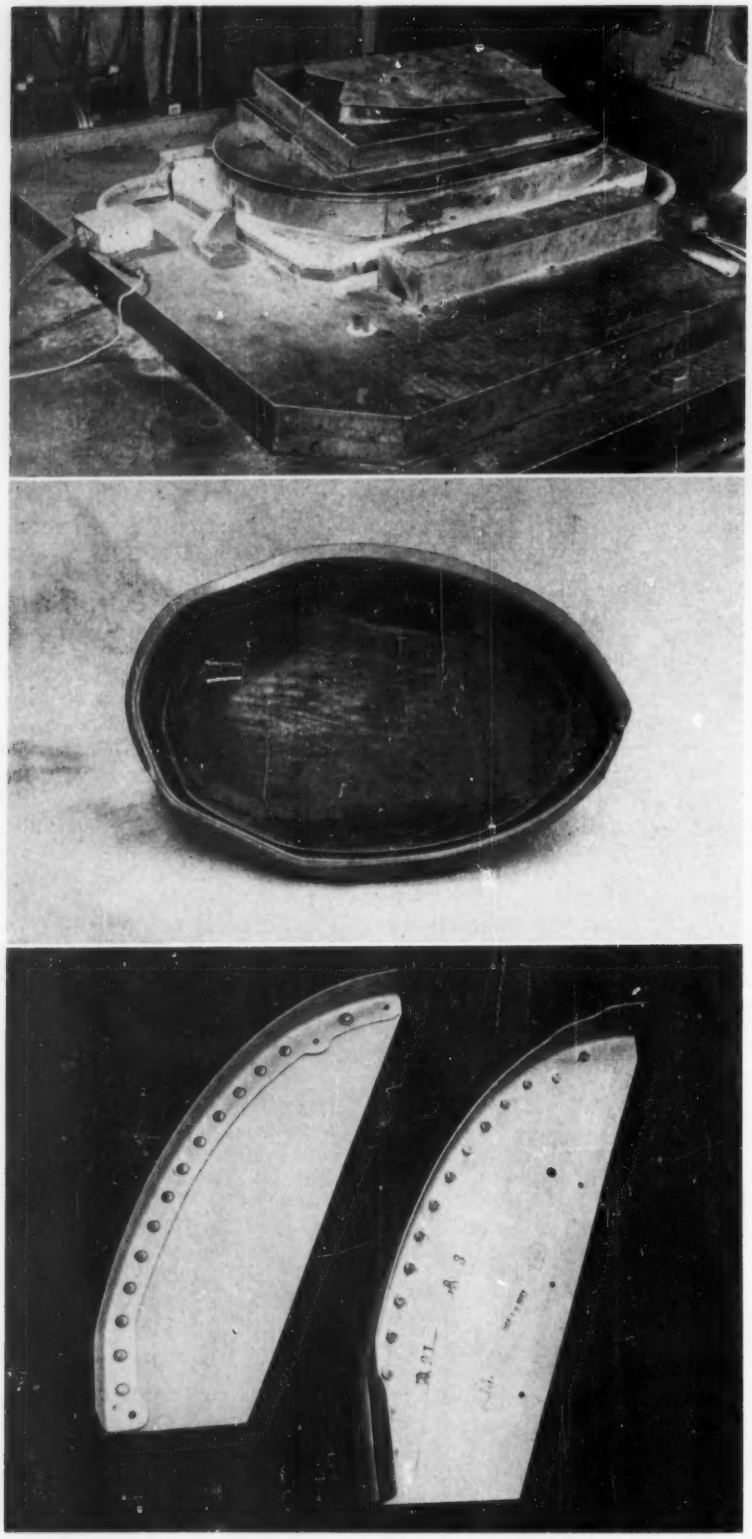
welding, and brazing. If any portion of the metal being joined exceeds 2500 F, recrystallization will occur and the thermally exposed portion will experience a considerable reduction in tensile strength. At present, inert-gas shielded arc welding with tungsten electrodes and argon or helium gas appears to be the most satisfactory method of welding heavy sheets and parts.

Molybdenum has been resistance welded by stamping or rolling a series of serrations or dimples into one of the sheets to provide projections for localized welding. Satisfactory spot welds can be made if the surfaces of the sheets to be joined are etched first.

Relatively thin molybdenum sheet is easily brazed with a spot or seam welder using copper or silver solder. Nickel foil or powder has also been employed as a brazing material. Heavy sections of molybdenum can be furnace brazed without flux in a hydrogen atmosphere. For applications requiring temperatures above the melting points of copper or silver solder, tantalum foil of approxi-



Molybdenum piercer points are used in making seamless stainless steel tubing (right). Machined parts (above) are used in megatron.



Heated die (top) maintains temperature in molybdenum blank during forming. Temperatures near 1200 F must be held for severe forming with several stages. Three-stage operation draws molybdenum into dish-shaped part (center). Trimming and addition of second riveted flange produce the finished piece (bottom).

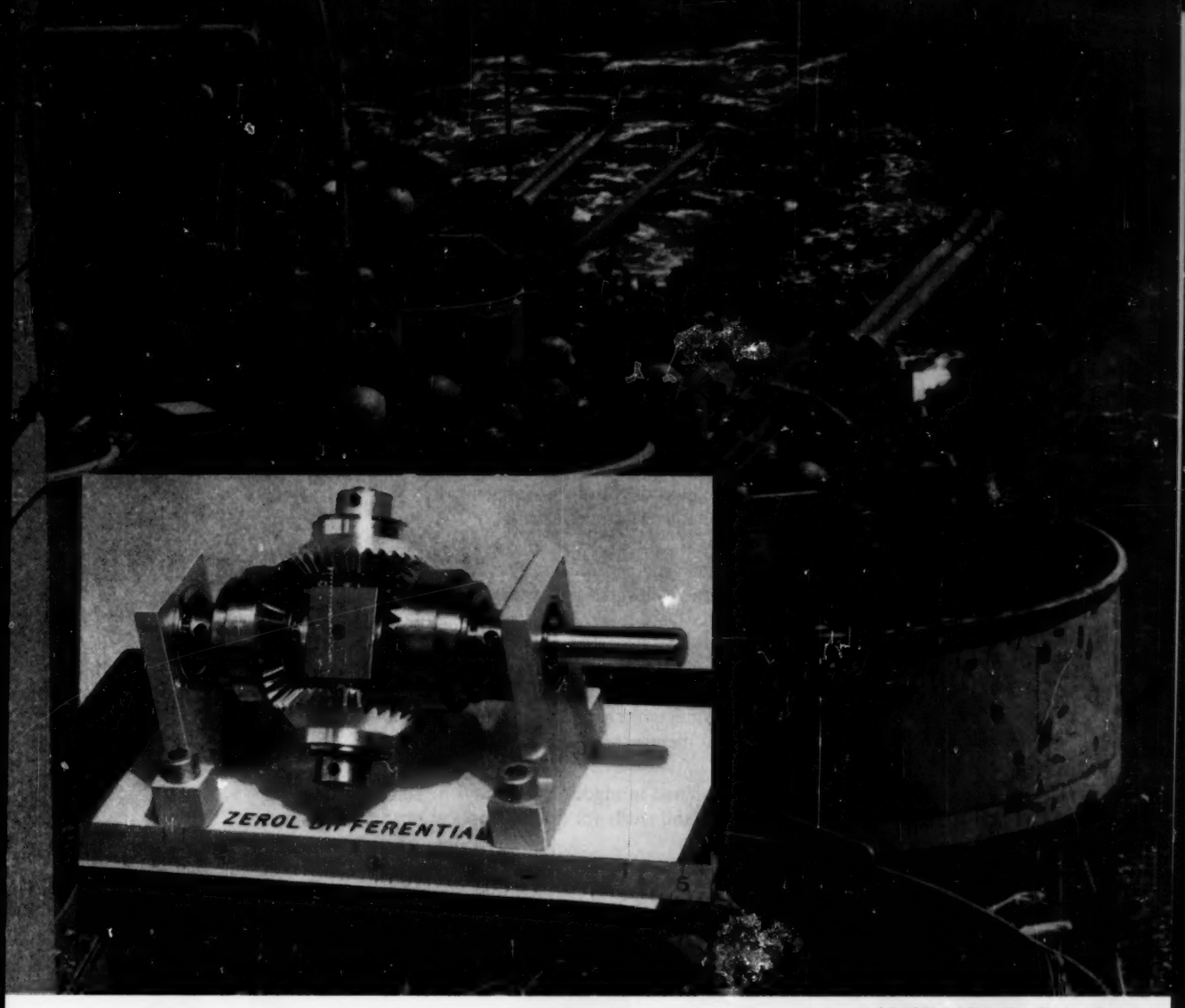
mately 0.001 in. thickness is an excellent brazing material. The tantalum foil is resistance "brazed" under water to prevent oxidation and to keep the molybdenum cool. Sufficient current is passed to melt the tantalum foil, but the molybdenum melts only imperceptibly even though it has a lower melting point than tantalum. This is because the molybdenum pieces are more massive and better cooled; also most of the heat is generated at the two interfaces. In service the tantalum diffuses into the molybdenum and practically disappears.

Pickling is seldom a problem with molybdenum because it is normally free scaling. A vapor or grit blast, or a molten caustic bath usually removes any oxide coating. Good results are obtained with a bath of 90 per cent potassium hydroxide, 10 per cent sodium nitrate at 600 F.

Save the Surface

Molybdenum's fast oxidation at moderately high temperatures, coupled with the fact that the oxide is volatile, results in complete disintegration of the metal at high temperatures. No molybdenum alloy has been developed with the desired combination of good oxidation resistance and strength properties at elevated temperatures. Therefore, development of a protective coating for molybdenum and its alloys has had much attention.

Cladding, sprayed-metal coatings, electrodeposited coatings, and ceramic coatings all have been applied to molybdenum. Of the electrodeposited coatings tried, electroplated layers of chromium and nickel appear to offer the greatest promise for applications up to 2000 F. Nickel, nickel-chromium, and Inconel have exhibited promise as cladding materials on molybdenum sheets of simple shape. Within certain limitations, sprayed-metal coatings have shown possible application for protection to temperatures as high as 2400 F. Despite disadvantages of low resistance to thermal shock, high stresses, and impact, ceramic coatings will probably find application for even higher temperatures because of their high melting point, chemical stability, and resistance to hot-gas erosion.



Official United States Navy Photograph

When your fine pitch gears *must be accurate*

When you work with fine pitch gears like those in this naval fire control unit differential, tolerances are critical.

Tooth-to-tooth accuracy is extremely important to permit the guns to be sighted precisely on target.

So where accuracy is really critical in the gears you make, Gleason can help you three ways:

1. Machines that cut or grind any fine pitch gear

You can produce any fine pitch gear—spiral bevel, hypoid, Zerol®, or Coniflex®—exactly and economically with any of five Gleason machines.

Three automatic gear-cutting generators cover the entire field of cut fine pitch bevel gears up to 4½" diameter. Two automatic, wet-type grinders are available for this same range of work and produce the ultimate in accuracy. All five work to your most rigid specifications.

2. Machines that test gears thoroughly

The Gleason No. 104 Hypoid Tester, for example, checks running qualities, tooth spacing, and concentricity of gears. It records test results on paper so that you have a permanent record of the total tooth-to-tooth composite error.

3. Engineering services

Gleason engineers are ready at all times to help you with any phase of the design and manufacture of fine pitch gears.

Simply write or phone for prompt assistance on any of your fine pitch gear requirements.

Send for these bulletins:

No. 2A Straight Bevel Coniflex® Generator
No. 103 Straight Bevel Coniflex® Generator
No. 2 Hypoid Generator
No. 105 Straight Bevel Coniflex® Grinder
No. 7 Hypoid Grinder
No. 104 Hypoid Tester

GLEASON WORKS
1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

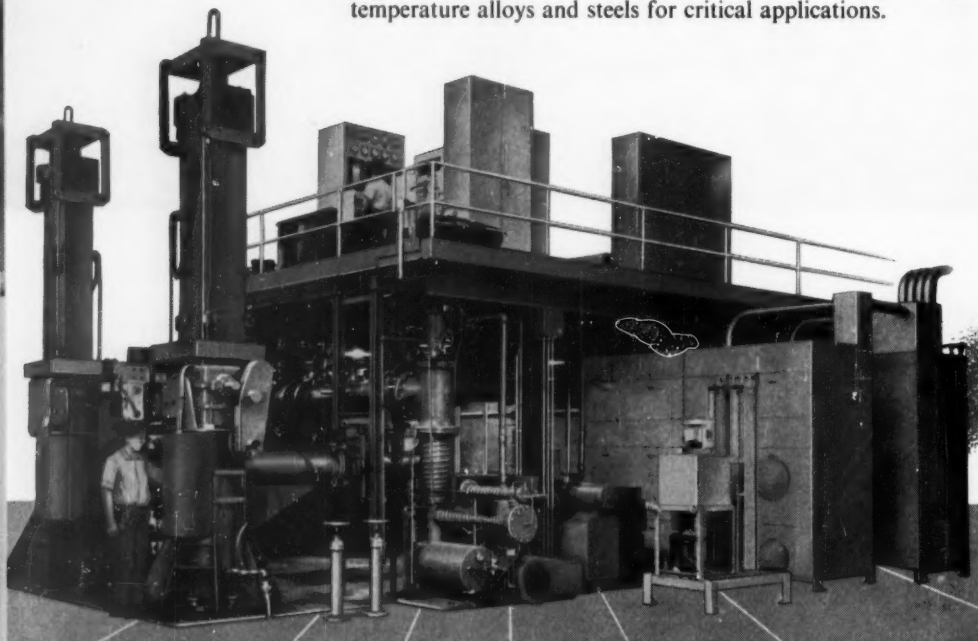
Circle 414 on Page 19

SUPER ALLOY STEEL BY *MIDVAC*
...A NEW STANDARD IN QUALITY

Steels to meet the exacting specifications of the aircraft, missile and bearings industries are being produced at Midvale-Heppenstall by the MIDVAC Process of consumable electrode melting.

Super alloy steels with increased tensile and impact . . . improved stress rupture strength at elevated temperatures . . . longer fatigue life. Midvac Steels are made for jet turbine and afterburner components and critical parts where strength is needed at temperatures above 1000°F. Steels for landing gear parts, retainer rings, compressor rotor blades. Steels for missile components such as combustion chambers, tail cone assemblies, nose cone or structural members.

Midvac Steels are offered in ingots, billets, and forgings of high temperature alloys and steels for critical applications.

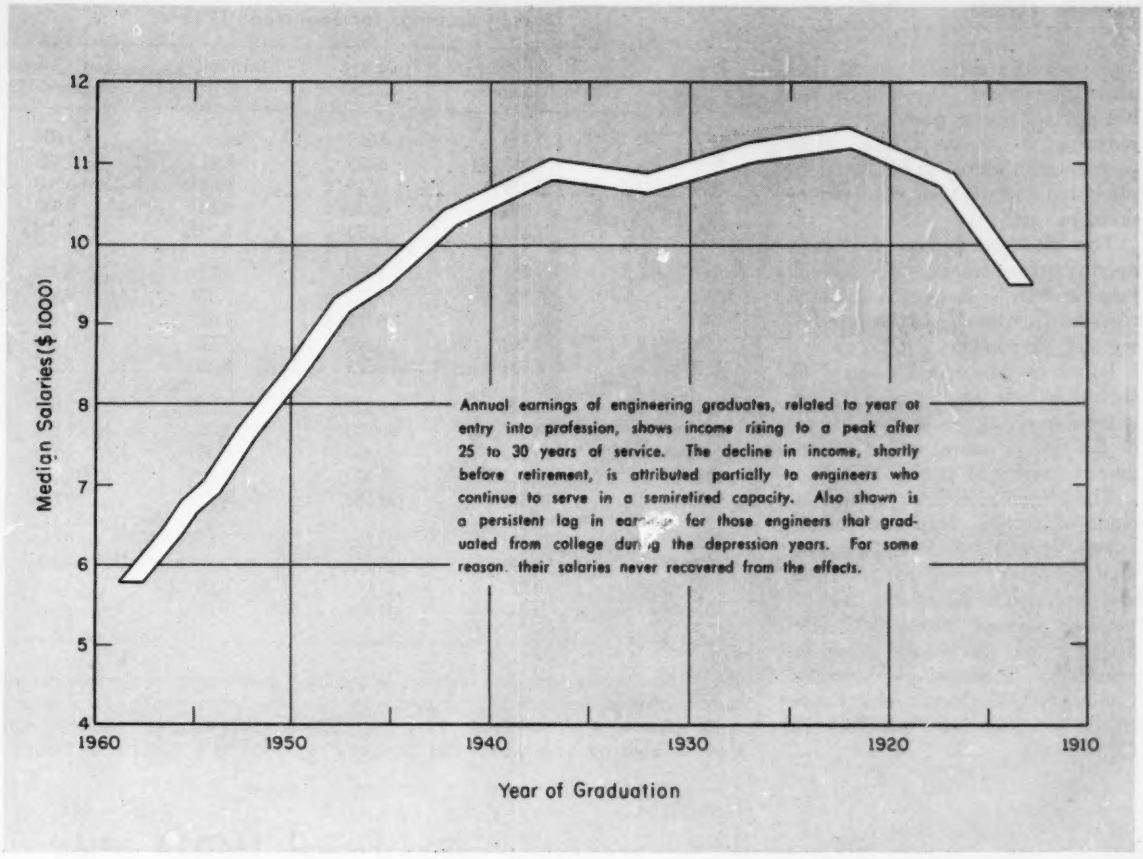


Circle 415 on Page 19

MIDVALE-HEPPENSTALL CO.

Nicetown, Philadelphia 40, Pa.

Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.


Median Salaries ($ 1000)
12
11
10
9
8
7
6
5
4
1960
1950
1940
1930
1920
1910
Year of Graduation
Annual earnings of engineering graduates, related to year of entry into profession, shows income rising to a peak after 25 to 30 years of service. The decline in income, shortly before retirement, is attributed partially to engineers who continue to serve in a semiretired capacity. Also shown is a persistent lag in earnings for those engineers that graduated from college during the depression years. For some reason, their salaries never recovered from the effects.

The most comprehensive analysis of engineers' earnings ever undertaken is being readied for publication by the Engineering Manpower Commission, Engineers Joint Council. Here's a summary of some of the pertinent figures on

ENGINEERS' PAY: 1958

NEW YORK—While nothing succeeds like excess, the remuneration received by engineers, in all categories of the profession, succeeds in showing a respectable upward trend at the rate of about 6.5 per cent annually. A 1958 salary survey, just completed by Engineers Joint Council, shows the 1958 median salary for all engineers in this country to be $8750.

In 1953 this figure was $6500 and in 1956, $7750, according to previous EJC surveys. During the two-year span from 1956-58, the Consumer Price Index rose 1.5 per cent, and the average gross weekly earnings for production workers climbed about 10 per cent.

Data for the 1958 survey are based on a big (190,810) cross section of engineers working in industry, government, and education. It shows that industry pay increases for the '56-'58 period closely parallel the over-all average (6.5 per cent).

Government increases, however, beat the average, which reflects the notable improvement that governmental agencies have been able to push through in the past two years. An example of this is the flat increase granted by Congress in 1958

for civil-service engineers in the Federal Government. The relative rise has not yet placed government employment in a competitive salary position with industry, but has definitely reduced the wide pay margins noted in past years.

The financial picture for engineering college teachers is also much brighter than in past years, although teachers' salaries still lag both industry and government.

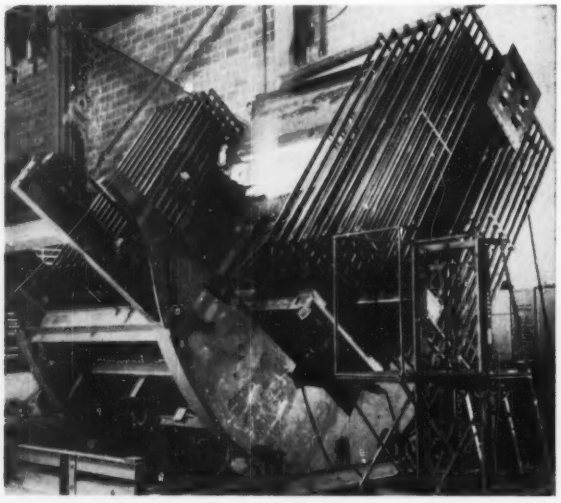
Extremes recorded by the 1958 survey include a total of 3313 engineers receiving an annual income of $20,000 or more, and 1530 engineers earning less than $5000.

The complete EJC survey will include some 23 industrial breakdowns. It will also include an age analysis of engineers in the U. S. and an analysis of trends in engineering incomes since 1953. Orders for the survey are being received by Engineering Manpower Commission, Engineers Joint Council, 29 W. 39th St., New York 18. Cost: $3.00.

Median Earnings for Engineers: 1958

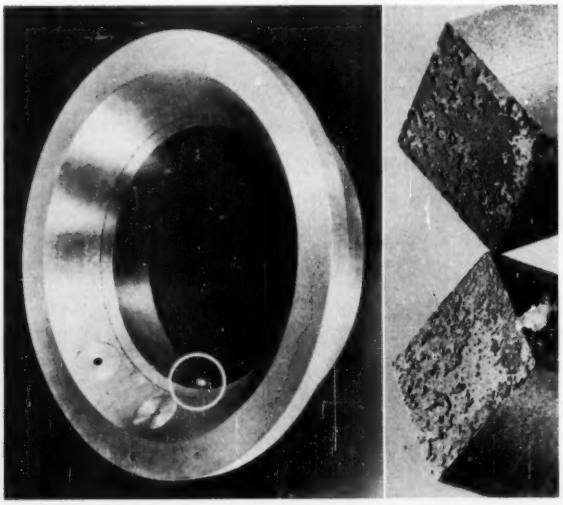
Year of Graduation	All Activities (190,810 Engineers)	Industry (155,124)	Government (30,028)	Eng. College Teachers (5139)
1958	$ 5,850	$ 5,925	$5,350	$ 5,600
1957	6,125	6,175	5,675	5,425
1956	6,475	6,525	6,075	5,700
1955	6,800	6,850	6,400	5,950
1954	7,000	7,050	6,700	6,225
1953	7,400	7,450	6,850	6,400
1952	7,700	7,725	7,075	7,100
1951	8,050	8,125	7,675	7,425
1950	8,350	8,450	7,775	7,500
1949	8,700	8,825	8,050	8,275
1947-48	9,200	9,325	8,325	8,625
1945-46	9,450	9,675	8,250	8,950
1940-44	10,250	10,450	9,050	9,875
1935-39	10,825	11,300	9,225	10,650
1930-34	10,675	11,350	9,325	10,850
1925-29	11,050	11,225	9,575	10,050
1920-24	11,200	11,850	9,425	10,650
1915-19	10,675	11,000	9,350	9,950
1914	9,500	11,000	9,225	9,175

The gaps dividing engineers' salaries in industry, government, and education are rapidly closing. Earnings of engineers in government continue to lag most seriously at experience levels beyond 12 years, while teaching salaries closely parallel those offered by government and generally lag $800 to $1000 below industry.



Welding Positioner Lies Down on the Job

Vertical and overhead welds are eliminated with a big positioner developed by General Electric Co. It's used to speed fabrication of 6-ton transformer tanks. The jig consists of an L-shaped frame with a turntable which traverses in and out on the short leg. A 3-hp motor rotates the frame through a 90-deg arc to lay the tanks on their sides. Component parts for tank assembly are hoisted aboard by jib crane. By simplifying welding operations, the positioner also improves weld quality and eliminates the need for a battery of overhead cranes formerly used.



Firebee Fixture Pasted Together from Scrap

New use for metal-to-metal adhesives has been developed by Ryan Aeronautical Co. Aluminum blocks were stuck together with Narmco Metlbond 4041 to form the blank for this fixture used in fabricating the Firebee target drone. Subsequent machining did not affect the bonded joints. Strength of bond is shown by bits of aluminum imbedded in the adhesive after test blocks were pulled apart. Ryan figures the process will save them about $20,000 annually in tooling costs. Metlbond 4041 is manufactured by Narmco Resins and Coatings Co., Costa Mesa, Calif.

Fulflo Filters
FOR COMPRESSED AIR AND OTHER GASES
• Remove moisture—oil—micro-co
• High or low pressure and capaci
Up in the air about filters?
Fulflo Filters with HONEYCOMB FILTER TUBES

this NEW booklet can help you!

What's the best way to protect your pneumatic equipment against moisture, oil, microscopic rust, dust, dirt and scale? CFC Fulflo Filters offer you a complete line of rugged, compact, single-tube and multi-tube models for compressed air — all described in this new booklet.

The booklet highlights Honeycomb Filter Tubes, the heart of Fulflo Filters. Single-tube Fulflo Filters are illustrated and described for operating pressures up to 125 psi, 250 psi, 450 psi, 750 psi and 4,000 psi. Multi-tube models are included for pipe sizes from 1½ NPT to 6 NPT, with from 3 to 270 Honeycomb Filter Tubes. Models are available in iron-and-steel, stainless steel, and nickel-plated brass.

Technical charts indicate flow characteristics and low pressure drop at various operating pressures. Physical dimensions of each filter are included.

Send coupon today for *your* new booklet.

COMMERCIAL FILTERS CORPORATION
MELROSE 76, MASSACHUSETTS
PLANTS IN MELROSE, MASSACHUSETTS AND LEBANON, INDIANA

MICRO-CLARITY AT MINIMUM COST

Fulflo Filters — *with genuine Honeycomb Filter Tubes for controlled micro-clarity of industrial fluids.*

CFC Systems — *Selective filtration of oils • water-oil separators • magnetic separators • pre-coat filters • coolant clarifiers • automatic tubular conveyors.*

COMMERCIAL FILTERS CORPORATION, DEP'T MD
2 MAIN STREET, MELROSE, MASS.

Please send me free booklet describing Fulflo Filters for compressed air.

Name & Title.....

Company.....

Street & No.....

City & State.....

FORMULA FOR REDUCED ASSEMBLY COSTS

You choose a tubular rivet for your design because of its low-cost efficiency. But what you save at the design stage may be lost in production unless parts are riveted with automatic riveters. Milford Tubular Rivets and Riveters should be paired for maximum cost savings. Mention this to your production engineers.

For the answers to assembly problems *get in touch with Milford first!*

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

Circle 417 on Page 19

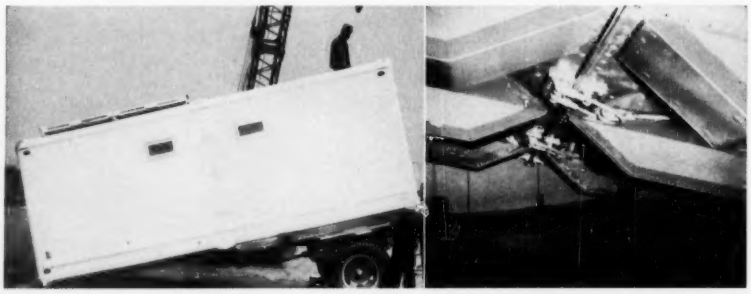
Knock-Down Lab Flies Anywhere

Giant Trunk Locks Make Rigid Field Assembly

MIDLAND, MICH.—An air-transportable magnesium van will house men and instruments sent by the National bureau of Standards to remote parts of the world. Weighing only 4000 lb, the two-piece lab can be transported fully assembled with running gear in cargo planes like the C 124. Single 10-ft sections can be carried by smaller aircraft and some helicopters.

Toggle latches on bottom and sides fasten quickly to make a rigid self-supporting body. Skid shoes, the only steel parts, are insulated from magnesium stringers by gaskets to avoid galvanic corrosion. Insulation and air conditioning protect men and sensitive equipment in all climates.

Elder Trailer and Body Inc., who designed the portable lab in co-operation with Raymond E. McGavin of the N.B.S. Laboratories, Boulder, Colorado, plans to market it for workshops, diners, radio stations, offices, and storehouses in hard-to-reach areas.



Self-sufficient in most climates, knock-down magnesium laboratory can be bulldozed on skids or drawn as conventional semitrailer. Over-all dimensions are 8 ft by 8 ft by 20 ft long. Individual 10-ft sections can be picked up, fully loaded, by a helicopter using eight lifting pads provided.

Hydraulics Blamed for Missile Misfires

System Designer Says Servos Need Improvement

DETROIT—Too many missiles, conceived with sound guidance and control schemes, default in flight because of poor hydraulic-system design, according to Raytheon's John W. Kastle. His two-part prescription: 1. Better translation of present-day theory into reliable hardware. 2. Advances in the state of the art, especially in hydraulic servo systems.

Speaking to industry attendees at Vickers' Aircraft Hydraulics Conference, the hydraulic-system designer for Lark, Sparrow, and Hawk missiles pointed to the need for major advances in the following areas:

• **Reduced null leakage:** Servovalve null-point leakage could, in short-range missiles, be the factor which decides between the relatively simple one-shot accumulator supply, or the complex, expensive, and heavy recirculating type.

• **Improved servo-valve solenoids:** Kastle expressed the opinion that the hydraulic servo field has lagged considerably behind the electrical servo field. Existing high-gain two-stage valves are already overtaxed, and a second generation of valves incorporating three stages is making its appearance. Higher-force electrical solenoids in reasonable envelope sizes are needed.

• **Higher dynamic response for valves:** Response of servo valves should be raised to the point where it is no longer the limiting characteristic in a system. Valve and actuator response should close out at no lower than 100 cps, with very high resolution at very low amplitudes. Degradation at temperature

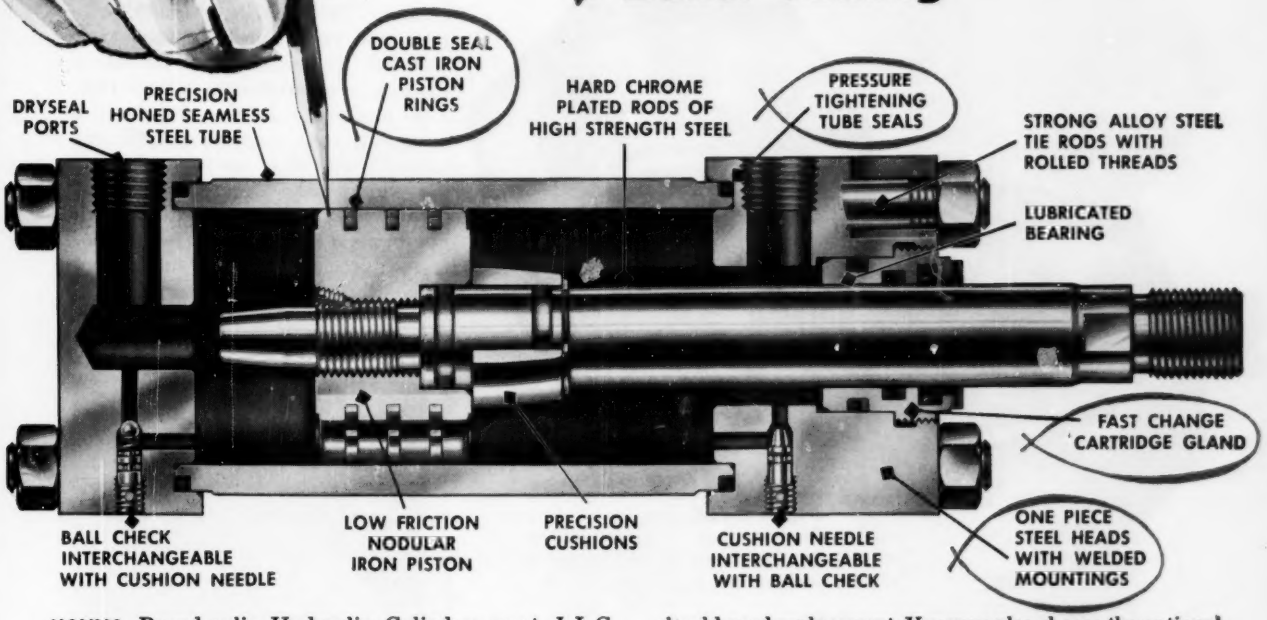
Your specifications

...a part of

Powrdraulic CYLINDERS

✓ **Greater Factor of Safety**

✓ **Better Sealing**


DRYSEAL PORTS
PRECISION HONED SEAMLESS STEEL TUBE
DOUBLE SEAL CAST IRON PISTON RINGS
HARD CHROME PLATED RODS OF HIGH STRENGTH STEEL
PRESSURE TIGHTENING TUBE SEALS
STRONG ALLOY STEEL TIE RODS WITH ROLLED THREADS
LUBRICATED BEARING
FAST CHANGE CARTRIDGE GLAND
ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS
CUSHION NEEDLE INTERCHANGEABLE WITH BALL CHECK
PRECISION CUSHIONS
LOW FRICTION NODULAR IRON PISTON
BALL CHECK INTERCHANGEABLE WITH CUSHION NEEDLE

HANNA Powrdraulic Hydraulic Cylinders meet J. I. C. recommendations and have industry standard mounting dimensions—2000 psi and 3000 psi non-shock. 1½" through 8" bores.

EXCLUSIVE PRESSURE TIGHTENING TUBE SEALS, located on the outside diameter of the cylinder tube, form a positive seal at all pressures from zero to maximum. Minute expansion of the tube due to pressure, squeezes the "O" ring making the seal even tighter. The "O" ring is fully confined between the head and the tube and will not extrude at high pressures. Unlike other cylinders that seal at the tube ends or inside diameter, the Hanna Powrdraulic Cylinder with pressure tightening O.D. seals will remain tight at all pressures.

DOUBLE SEAL PISTON RINGS give you twice the sealing power of conventional piston rings. These bi-directional, cast iron rings, consisting of a ring within a ring, seal both the "in" stroke and the "out" stroke of the cylinder. The piston with double seal rings is packed for life and never should need replacement. You may also choose the optional piston with "U" type synthetic packings.

FAST CHANGE CARTRIDGE GLAND equipped with a leak proof, low friction rod seal forms a tight seal from zero to maximum pressure. Built in rod wiper removes dirt and particles from piston rod as the rod moves "in" and serves as another hydraulic seal to wipe the rod dry on the "out" stroke. You can select either the standard gland or the optional, multiple lip, spring loaded seal. The optional gland is interchangeable and is available with synthetic rubber or Teflon* Vee packing.

ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS are much stronger than conventional bolted construction and assure squareness of mountings. All mountings are designed to carry maximum cylinder loads with a generous safety margin.

Write for Catalog 900 and the name of your nearest representative.

*DuPont's registered trademark.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT...CYLINDERS...VALVES

1751 Elston Avenue Chicago 22, Illinois

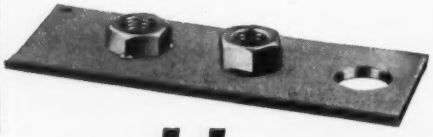
Circle 418 on Page 19

FOR BETTER
product appearance
FOR FAST
low cost assembly

RECESSED TYPE
Recess avoids clogging of threads by weld flow or spatter—no re-tapping.

PILOT TYPE
Provides quick, accurate positioning. Pilot forms barrier preventing weld spatter in threads.

M·F



projection weld nuts

Solve production delays—cut manufacturing costs. Fuse nut to the product in exact location. Engineered for assembly simplification. The welding of nuts to subassemblies permits the use of screws or bolts in the main assembly without the need for holding nuts from turning, cutting time and labor.

Both types available with the patented *M·F Two-Way®* or famous *M·F UNI-TORQUE®* locking feature.

M·F weld projections are uniform in height and volume of material to insure uniform electrical contact and result in clean, strong, dependable welds.

M·F weld nuts are designed to give a 3-point bearing, eliminating rock and guaranteeing a uniform weld.

Concealed fasteners for improved product appearance.

Pre-attached fasteners in blind locations for faster, trouble-free final assembly . . . improve design . . . cut costs.

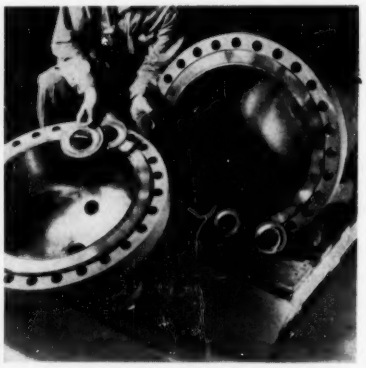
Send for descriptive literature.

MAC LEAN-FOGG LOCK NUT COMPANY
5535 N. Wolcott Street, Chicago 40, Ill.

extremes should be minimized.

• **Integrated packaging:** Many missile designers are not taking full advantage of the cartridge-type component, with its possibilities for reduced weight and space. Future designs will force abandonment of the aircraft approach which calls for individual hydraulic components and extensive plumbing.

• **Vibration and acceleration tolerance:** Unlike other hydraulic components, which are relatively unaffected by acceleration, the servo valve is often thrown off by high g loadings. Kastle suggested a stability test employing 2000 cps at 35 g's, with random vibration superimposed. There is growing interest in a testing procedure which subjects a component to simultaneous acceleration, vibration, and temperature extremes.



Pressure Cooker Passes Acid Test

Tantalum lining that resists acid corrosion and mechanical wear is made possible in this 30-gal industrial vat through the use of special tantalum processing techniques developed by two co-operating companies. Using vacuum arc casting, Haynes Stellite Co., Div. of Union Carbide, Kokomo, Ind., was able to increase its commercial ingot size and produce 0.30 in. thick rolled sheets large enough for the lining. The Pfaudler Co., division of Pfaudler Permutit Inc., used an inert-gas chamber to arc-weld the sheet into liner form. No specific limit has been set on the size of liners that can be made by this process. All parts of the vat that come in contact with its contents are tantalum or tantalum coated, including agitator, agitator shaft, baffles, and immersion type heater. A stainless-steel jacket gives the vat strength to withstand 500 psi at 650 F.

Circle 419 on Page 19

AEC's Big Problem: Evaluate 1700 Reactor Types

Scale Models, Mathematics Won't Tell the Full Story

WASHINGTON—The recent decision of AEC to concentrate on commercial development of five types of nuclear - reactor powerplants solves (perhaps temporarily) one of the toughest problems faced by the Commission since its inception.

While five reactors (1. boiling water, 2. organic moderated, 3. gas cooled, 4. fast breeder, 5. liquid fuel) would seem to bracket the field fairly well, there are some 1700 different types that would theoretically perform successfully. And the Commission is faced with the knowledge that its scientists today lack sufficient knowledge to understand the precise potential of any one reactor.

Problems involved in picking the reactor most likely to succeed were outlined by AEC Commissioner John F. Floberg at the recent Winter Meeting of the American Nuclear Society.

Competitive vs. Cheap Power: Simple economics is one of the key factors in the Commission's evaluation of the various reactor types. AEC has emphasized its intention of producing *cheap*, not *competitive* power. This will provide enormous gains in the material well-being of the nation.

Big vs. Small: The economic promise of nuclear power, as developed to date, seems greatest where very large plants (200,000 kw and up) can be operated at high load factors. However, it is important also that the U. S. develop small plants for use in underdeveloped countries. AEC is thus forced to be active on two fronts.

Time vs. Cost: While the pinch in domestic supplies of fossil fuels is still quite a few years away, political and economic pressures — national prestige, competition from foreign markets—forces U. S. development efforts to proceed at top speed. This poses the second major problem faced by AEC.

Speed and cost—in nuclear research and development—are prob-

Daddy isn't the boss...

He's just in charge of putting gears in the machines. But he doesn't growl anymore when he comes home. Mommy says he doesn't worry now about bad gears and not getting them on time since they buy them from CINCINNATI GEAR.

Why not investigate the advantages of having your gears and gear boxes made to suit your needs exactly? CINCINNATI gears are precision made, precision inspected, GUARANTEED—with delivery dates as promised. Ask us to quote on your requirements.

CINTI®

THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

GEARS, good gears only

Circle 420 on Page 19

REEVES® *Vari-Speed MOTOR PULLEY*

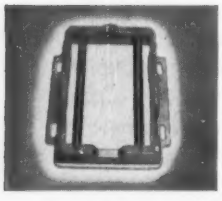
Here is variable speed control in its most simplified form . . . variable speed control with new economy.

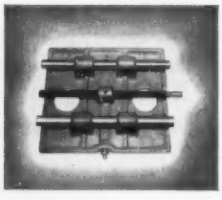
Disc assemblies have just three main parts: two smooth-face, cone-shaped discs; and the belt tension spring. There are no other wearing parts to give maintenance trouble. Compact disc assemblies available in nine sizes, ½ hp. through 15 hp., to fit both old and new NEMA motors.

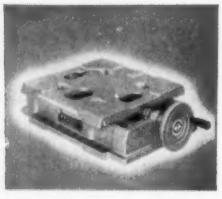
Separately mounted countershaft assemblies are available. For complete information on sizes and available controls, write for Bulletin H36b-V582.

Split section view of sliding disc shows how REEVES "close grooving" maintains film of lubricant between hub length of fixed disc and bore of sliding disc. One lubrication point services entire disc assembly.

New precision bases Four compact sizes to accommodate old and new NEMA motors in ½ through 15 hp. Sturdy bases are specially manufactured to assure positive, easy adjustment and accurate speed control.







Base and motor slide rods manufactured for precision fit and true alignment. Fully-lubricated shifting screw and precision features provide easy shifting.

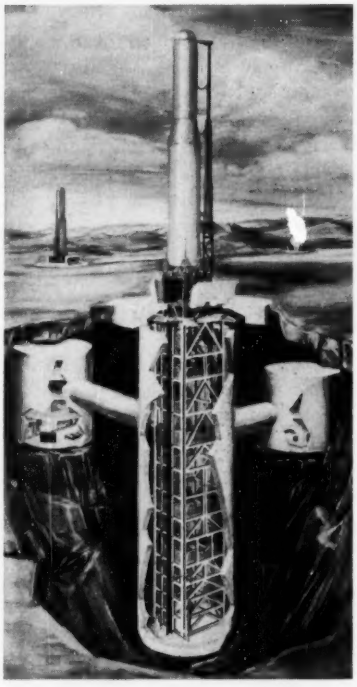
REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

ably geometrically proportional, simply because the only way to measure performance of a nuclear powerplant is to build one. Scale models and mathematical calculations provide no accurate means of predicting final performance of a full-scale installation.

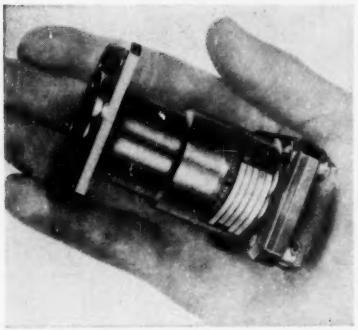
AEC's steady, hard-won progress, while not spectacular, characterizes the Commission's intention of developing the best possible designs with the least cost in manpower and money.



Hole in the Ground for Titan

The familiar above-ground gantry system will be eliminated on Titan ICBMs. Fueling and preflight checkouts will be accomplished in unobtrusive underground service areas, and the sophisticated missile will be hoisted to the surface for firing only. The launching complex, developed by American Machine & Foundry Co., will protect the big weapon from almost everything except a direct nuclear hit. Titan is Air Force's second-generation ICBM, the step between Atlas and the solid-propelled Minuteman. Since Minuteman will also be a cave dweller, Titan launching silos may be designed to accommodate both missiles, with changes only in support equipment.

Circle 421 on Page 19



Fast Pump Takes Direct Drive

Operating at 24,000 rpm—fast enough for direct drive from high-speed turbines—this 1.1-lb, hydraulic pump delivers 2.5 gpm at 3000 psi. It has run under load for 50 hr without appreciable loss in efficiency. Used as either pump or motor without modification, it is equally efficient rotating in either direction. The pump, called Hummingbird, is available for aircraft and missile applications as an auxiliary hydraulic-pressure supply, or as a hydraulic motor to drive alternators or other components which can not be driven directly because of location or special requirements. The developer, Pesco Products Div., Borg-Warner Corp., Bedford, Ohio, claims a new constant-speed universal joint is one of the secrets of the pump's performance.

Gravity Still Baffles Scientists But Research Gains Momentum

Wanted: Containers for Antimatter And a Gravity Transfer Agent

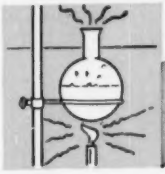
NEW BOSTON, N. H. — This year marked the 10th anniversary of the Gravity Research Foundation, an event that was celebrated during the annual Gravity Day meeting of 278 leading scientists and engineers in New Boston, N. H.

Results of the meeting, just published, reveal no earth-shaking explanations or solutions to gravity, but point to the tremendous increase in organized, diligent research being carried out by a great number of established concerns and prominent scientists. For example, all leading aircraft manufacturers were represented at the meeting.

Professor Howard O. Stearns, board chairman of the Foundation, said letters and papers attempting

(Please turn to Page 40)

ACIDS, CORROSIVES AND SOLVENTS

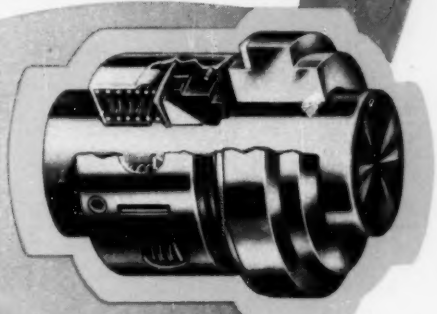


HOT LIQUIDS

TOXIC GASES AND VAPORS

JOHN CRANE

TYPE 9 MECHANICAL SEAL



WILL HANDLE THEM ALL!

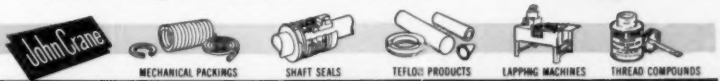
Wedge and sealing rings molded from DuPont Teflon assure efficient, safe handling of all known industrial chemicals and corrosives at temperatures varying from −120°F. to +500°F. Spring and metal parts are furnished in the metallurgical specification best suited to the particular service. In every way, you get a mechanical seal that is "John Crane" engineered to your requirements—no matter how tough!

The Type 9 Seal has and continues to solve innumerable problems where difficult-to-handle liquids and gases are involved . . . at pressures up to 750 psi. It can do the same for you.

Use the Type 9 Seal on all rotating shaft equipment—centrifugal and rotary pumps, mixers, agitators, autoclaves, other equipment.

For full design and other engineering details request Type 9 Shaft Seal Bulletin S-205-3.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*



CRANE PACKING COMPANY

Circle 422 on Page 19 Circle 423 on Page 19→

Get dependable operation, increased

quality for your product...

GENERAL ELECTRIC TRI 55 CLAD MOTORS PROVE THEY PROVIDE IT BY PASSING TORTURE TEST

HERE'S HOW: G-E Tri/Clad '55' polyphase motors are more fully enclosed than ordinary dripproof motors. This extra protection makes them suitable for many jobs which normally require splashproof motors . . . extra protection at no extra cost.

Mylar* polyester film slot and phase insulation, non-wicking leads, and water-resistant stator coating give long-life protection against *moisture*. Formex† magnet wire provides protection against heat-aging and *dirt*. Heavy-duty bearing system keeps lubricant in, abrasive dust out. And rigid cast-iron frame and endshields and melamine paint finish protect G-E motors against *external damage*.

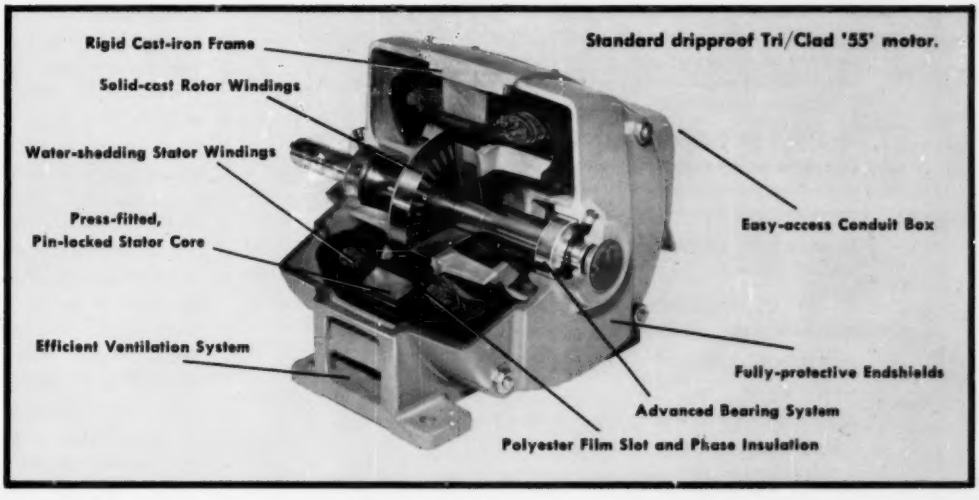
*Registered Trade-mark of DuPont Co.

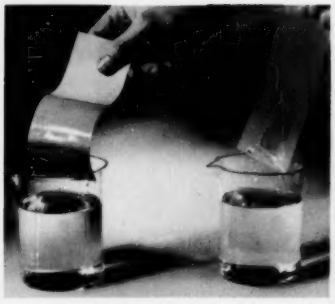
These are just some of the outstanding Tri/Clad '55' motor features which mean longer life, more dependable operation—improve the quality and saleability of your product at no extra cost to you *or* your customers!

CONTACT your nearest G-E Apparatus Sales Office for *personal proof* on how G-E Tri/Clad '55' motors can give better operating protection to your products. And ask for your free copy of descriptive bulletins, GEA-5980 and GEA-6602, or write to Section 840-19, General Electric Company, Schenectady 5, New York.

†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC

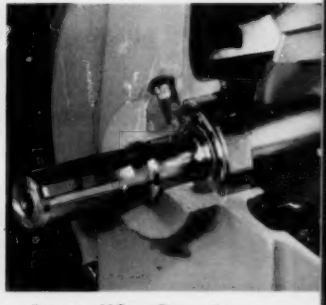




Mylar Insulation protects against moisture; assures longer motor life, minimum maintenance.

Water-resistant Coating applied to every stator assembly virtually eliminates insulation failure due to moisture.

Formex Wire insulation will not break under severe conditions—protects against heat-aging and abrasive dust.



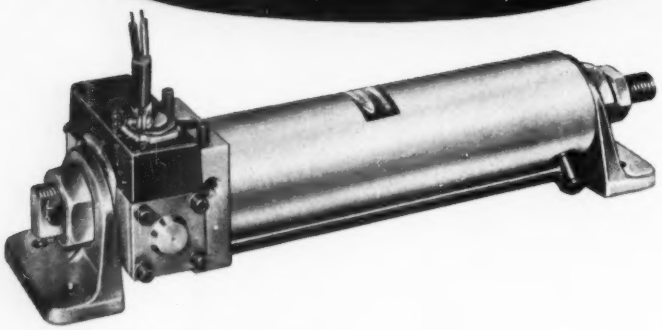
Long-life Bearing System seals dirt out, has new longer-lasting grease, can be regreased.

Now-SAVE SPACE, WEIGHT & PIPING

with **NEW**

Modernair
Trademark

VIH (VALVE-IN-HEAD) CYLINDERS



Here's a combination that's hard to beat—a performance-proved industrial air cylinder with its own built-in directional and exhaust speed control valves—in a single, compact "package". Check these important features:

- **BUILT-IN DIRECTIONAL CONTROL VALVES...** your choice of four control combination; double solenoid, single solenoid with button bleeder return, double button bleeder, or double remote pilot pressure operation.
- **BUILT-IN EXHAUST SPEED CONTROLS** with automatic Nylon lock.
- **INTERCHANGEABLE MOUNTINGS...** front or rear flange, low or high "L" foot brackets, rod and cylinder clevis.
- **SINGLE CONDUIT CONNECTION** for double solenoid unit.
- **AVAILABLE WITH CUSHIONED STOP** either or both ends.
- **PERFORMANCE-PROVED MODERNAIR CONSTRUCTION**

Condensed Specifications

DIAMETERS: 1½", 2", 3"
ROD SIZES: ½", ⅝", ¾"
MIN. OPERATING PRESSURE: 20 p.s.i.
SOLENOID POWER REQUIRED: 10 watts
MAX. OPERATING PRESSURE: 150 p.s.i. (solenoid) 200 p.s.i. (bleeder or pilot pressure)
SOLENOID COILS AVAILABLE: (ac) 8-10, 110, 220 v. (dc) 12, 24, 30 v.

Call your local MODERNAIR sales outlet (see Modernair trademark under "CYLINDERS" in the yellow section of your phone book) or write us today for complete data bulletin; please address Dept. E-1

Modernair **CORPORATION** 37
400 Preda Street · San Leandro, California
MEMBER NATIONAL FLUID POWER ASSOCIATION

(*Continued from Page 37*)

to explain gravity are pouring into the Foundation at an unprecedented rate. He also said there are several major pitfalls into which many of the writers fall: Some writers attempt to start from scratch, with a mind uncluttered by knowledge, to develop a wholly new theory. They come up with "original" ideas that have been known to scientists for the past 50 to 2000 years. Other writers stumble over the need for dimensional consistency in statement and equations.

According to Professor Stearns, most of the papers received by the Foundation can be classified into one of the following categories:

- An attempt is made by some writers to revive the theory of vortices, put forth originally by Rene Descartes. Newton, in the *Principia*, pointed out the fallacies of any vortex theory.
- The inflowing ultramundane-particle theory of LeSage, or some modification thereof, is attractive to a large group of writers. Defects in this theory were stated by G. H. Darwin more than 70 years ago.
- The idea that a gyroscope can be induced to take off into interstellar space is being researched in some quarters. Success here is generally considered to be as likely as lifting oneself by the bootstraps.
- The use of antimatter to counter the force of gravity appeals to many researchers. However, since antimatter unites with ordinary matter destructively, there is naturally no way of containing it.
- Neutrinos are being investigated as a possible explanation to the mysteries of gravity—with the idea that gravitation may be due to exchange forces among neutrinos and matter.
- The possibility that gravity may be some kind of second-order effect of electromagnetism is being studied by several prominent scientists.

Annual prizes for the five best papers presented during the year were awarded at the close of the meeting. First prize went to Professors Giuseppe Cocconi and Edwin Salpeter of Cornell University. They pointed out some aspects of present gravitational theories that must be shown to be deficient in order to develop a more inclusive theory.

Metals Matters

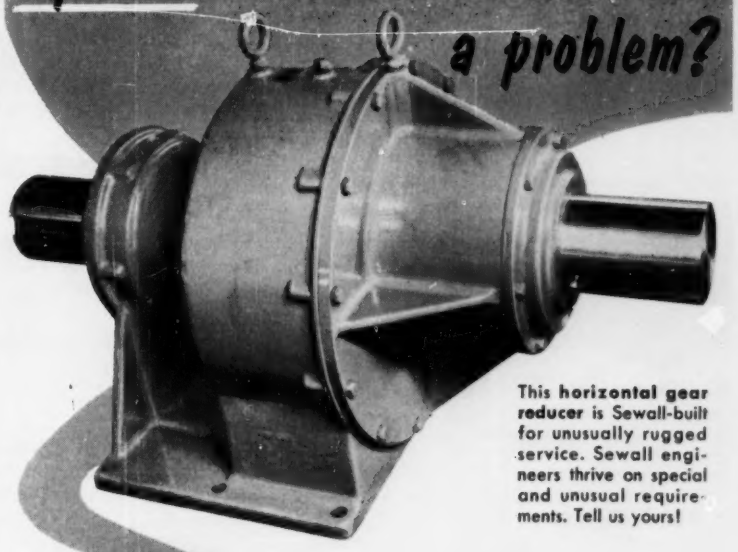
Everything turns into metal . . .
even hydrogen, if it's exposed to high enough pressures. This is a recent prediction of experimenters at the University of California. They've already converted phosphorus—ordinarily an insulator—into a conductor of electricity by compressing it under 150,000 atmospheres (2,250,000 psi). At this pressure, electrical resistance of the phosphorus was reduced 10,000,000 times, which can be explained only on the basis that it had actually become a metal. The same effect was observed in silver oxide, a semiconductor.

New "nuclear" steels . . .
with extremely low manganese and cobalt content, have been developed by Jones & Laughlin Steel Corp. Aim was to solve the problem of retained radioactivity common to standard-steel reactor equipment, a phenomenon which makes reactor repair and adjustment difficult. J & L minimized thermal-neutron-generated radioactivity in the new steels by dropping Mn and Co content, substituting elements like titanium to give the best combination of nuclear and mechanical properties. The nuclear-steel series has formability, weldability, and strength characteristics suiting it for use in non-nuclear fields.

Hot-soak for 1000 hr . . .
at a temperature of 1100 F left a new Armco stainless steel (22-4-9) with a hot hardness of Brinell 250. Initial room-temperature hardness was Brinell 344. The corrosion and heat-resistant stainless is for applications such as steam valves and gas-turbine parts that operate in the 900 to 1600-F range. Low in nickel content, the steel is austenitic, resists wear, erosion, and galling, and is nonmagnetic.

Superpure chromium . . .
which contains no single metallic or gaseous impurity in quantities greater than 10 parts per million, has been developed by Battelle Memorial Institute. Until now, chromium's lack of ductility limited its use in high-temperature alloys. The superpure chrome, called Iochrome, has demonstrated 44 per cent elongation and 78 per cent area reduction. This permits its addition to alloys in amounts 5 to 10 per cent greater than in the past. Immediate application of Iochrome, marketed by Chromalloy Corp., White Plains, N. Y., will be in gas-turbine and reactor alloys.

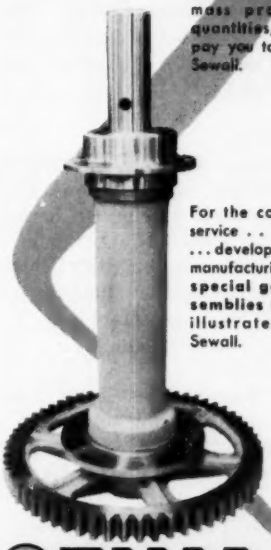
Special GEAR BOXES a problem?



This horizontal gear reducer is Sewall-built for unusually rugged service. Sewall engineers thrive on special and unusual requirements. Tell us yours!

Announcing!

Whether you need gear boxes such as this worm gear reducer in custom or mass produced quantities, it will pay you to talk to Sewall.



For the complete service . . . design . . . development . . . manufacturing . . . on special gear assemblies (sample illustrated) call Sewall.

A new Sewall Service . . . designing, development and manufacturing . . . to help solve your special gear box problems . . . effectively . . . economically. We're ready to work with you at any stage of your project's development.

From scratch . . . our gear box designers will go to work for you right now. Give us a rough outline of your idea. We're staffed and equipped to design and manufacture gear boxes whatever the size and description of your requirements.

To your specifications . . . let us submit our quotation on producing your order in strict accordance with your prints. Sewall gear boxes are made by men who are fussy about specifications. Your order must be delivered as scheduled . . . priced right. Let us hear from you!

Sewall's complete gear service can help you . . . custom made gears . . . made-to-order sprockets . . . special gear racks—to order . . . standard gear racks in stock.

SEWALL GEARS

E. B. SEWALL MANUFACTURING COMPANY
705 Raymond Avenue, Dept. A, ST. PAUL 14, MINNESOTA, Midway 5-7721

Circle 425 on Page 19

Machine Design Appoints Assistant Editor

CLEVELAND—Stanley G. Cook has joined the staff of MACHINE DESIGN as an assistant editor. Mr. Cook holds a B. S. degree in electrical engineering from Purdue University. Since 1951 he has been associated

Stanley G. Cook

with Jack & Heintz Inc., Cleveland, where he was a project engineer on dc generators.

His present assignment includes preparation of the Engineer's Library and editing of technical articles.

Meetings

AND EXPOSITIONS

Jan. 21-23—

American Society for Engineering Education. Engineering Graphics Div. Mid-Winter Meeting to be held at Wayne State University, Detroit. Further information can be obtained from Robert B. Thornhill, Assistant Professor, Engineering Graphics, College of Engineering, Wayne State University, Detroit 2, Mich.

Jan. 26-27—

American Society of Lubrication Engineers. First Annual Gear Symposium to be held at the Morrison Hotel, Chicago. Further information can be obtained from ASLE, 84 E. Randolph St., Chicago 1, Ill.

Jan. 26-29—

Institute of the Aeronautical Sciences. Annual Meeting to be held at the Sheraton-Astor Hotel, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 26-29—

Plant Maintenance and Engineering Show to be held at Public Auditorium, Cleveland. Additional information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 26-29—

Fourteenth International Heating & Air Conditioning Exposition to be held at Convention Hall, Philadelphia, under the auspices of the American Society of Heating and Air-Conditioning Engineers. The society's 64th annual meeting will be held concurrently. Further information can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Feb. 3-5—

Society of the Plastics Industry Inc. Fourteenth Reinforced Plastics Conference to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 15-19—

American Institute of Mining, Metallurgical, and Petroleum Engineers. Annual Meeting to be held at the St. Francis Hotel, San Francisco. Further information is available from AIME headquarters, 29 W. 39th St., New York 18, N. Y.

March 9-10—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 11-13—

Pressed Metal Institute. Spring Technical Meeting to be held at the Pick-Congress Hotel, Chicago. Further information can be obtained from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

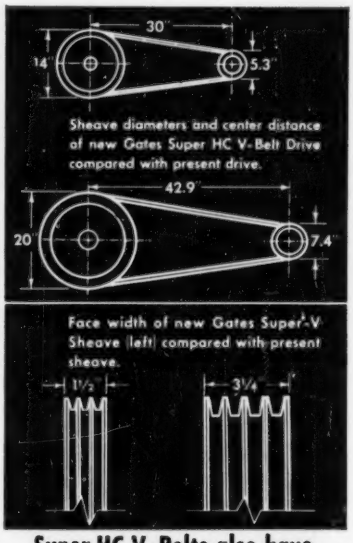
How savings multiply with new Gates Super HC V-Belt Drive

The cost of a new Gates Super HC V-Belt Drive is as much as 20% less than the cost of a drive of comparable hp using present V-belts. But the lower cost of the drive itself is only the initial *purchasing* economy.

Further economies are realized on drive equipment, such as housings and bases — economies in materials, production time, shipping costs.

Shown below are space savings of a typical installation . . .

	Present Drive	Super HC Drive
DriveR Sheave	7.4	5.3
DriveN Sheave	20.0	14.0
Center Distance	42.9	30.0
Belts	4-B128	3-3V900



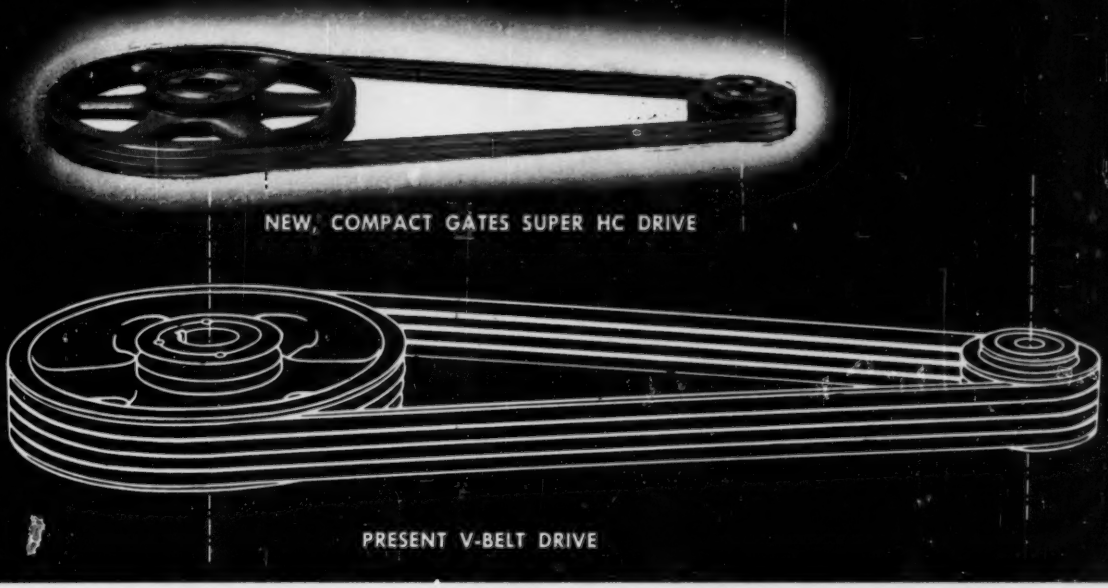
Super HC V-Belts also have these important Gates features...

1. **Flex-Weave Cover** (U. S. Pat. 2519590) A Gates exclusive. Makes cover more flexible . . . prolongs belt life.
2. **Concave Sidewalls** (U. S. Pat. 1813698) become straight as belt bends insuring uniform contact with sides of groove. Uniform contact means less wear . . . far longer belt life.
3. **High Electrical Conductivity** is built in for safer drives in explosive atmospheres.
4. **Oil, Heat and Weather Resistance** is insured by use of special rubber compounds.

Gates

Circle 426 on Page 19

New high capacity V-belt revolutionizes drive design



Makes drives far more compact... cuts cost as much as 20%

Here is a major advance in the field of power transmission — the fully proved Gates Super HC V-Belt, developed in the world's largest belt-testing laboratories at The Gates Rubber Company.

With the Gates Super HC V-Belt, you can have the lowest-cost, lightest-weight, most compact multiple V-belt drive you can put on any machine! Sheave diameters can be reduced up to 50%, sheave widths 30% to 50%, center distances 20% and more!

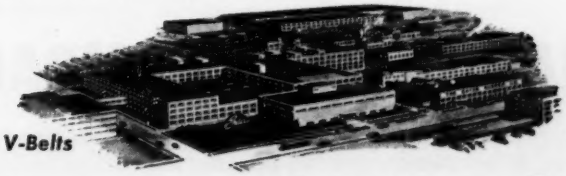
On new drives, the cost of a Gates Super HC V-Belt Drive is as much as 20% less than present V-belt drives of the same hp capacity!

Learn More About The Cost-Saving Super HC Drive

For detailed information on the Super HC Drive, contact your nearby Gates distributor or Gates Office for new booklet, *"The Modern Way to Design Multiple V-Belt Drives."* For utmost space, weight and dollar savings in new drives or drive replacements, specify Gates Super HC V-Belts and Sheaves. Stocks immediately available in principal industrial centers.

The Gates Rubber Company Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates
World's Largest Maker of V-Belts



Gates Super HC V-Belt Drives

Circle 427 on Page 19

the spirit of '76...

THE SPIRIT OF '76 . . . exemplifying strength —dependability—determination to move forward through the years.

Wyman-Gordon enters its 76th year still forging ahead with new forging techniques—still meeting the challenge of the seemingly impossible in this age of power and speed on the ground—in the air—and in outer space.

It is a far cry from the modest beginning in 1883 to the forging industry's most modern testing and research facilities in the extensive laboratories of Wyman-Gordon today—assurance of the ultimate in forging quality.

From the high wheel bicycle through the "horseless carriage" days to the "Mach era" of aircraft and space vehicles, Wyman-Gordon has marched under the standard of "The Greatest Name in Forging."

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS
HARVEY, ILLINOIS • DETROIT, MICHIGAN

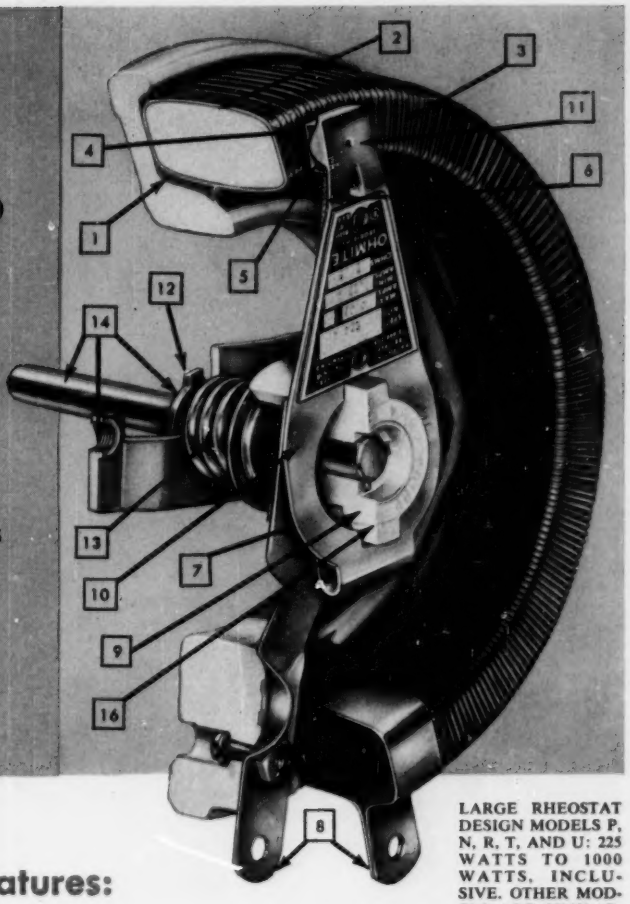
Smooth Close Control

OHMITE®

RHEOSTATS

NOW 11 Sizes! 12½ to 1000 Watts

Ohmite offers you industry's most complete line of rheostats. All sizes are available from stock in a wide range of resistance values, including the NEW Model "E." Ten sizes are available to meet MIL-R-22A requirements in *each* of the 26 type designations.



LARGE RHEOSTAT DESIGN MODELS P, N, R, T, AND U: 225 WATTS TO 1000 WATTS, INCLUSIVE. OTHER MODELS ARE SIMILAR.

16 Quality Engineering Features:

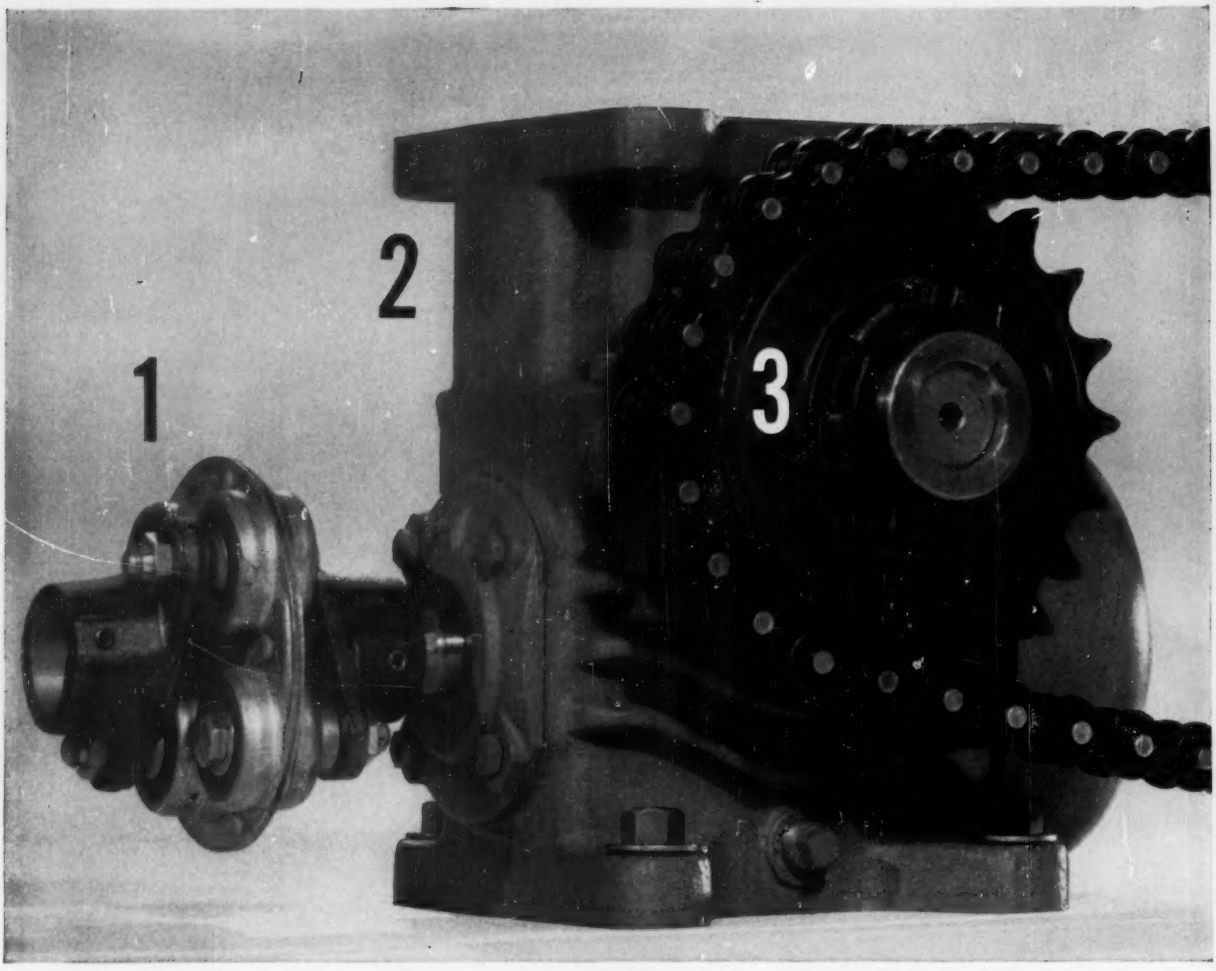
1. Vitreous enamel bonds the core and base together into one integral unit.
2. The wire is wound over a solid porcelain core, and each turn is locked against shifting by vitreous enamel. Uniform or tapered winding.
3. Close graduation of control. Each turn of wire is a separate resistance step.
4. Large, flat surface upon which the contact brush rides.
5. Metal-graphite contact brush (varied to fit current and resistance) insures good contact, with negligible wear on the resistance wire.
6. Shunt pigtail of ample size carries the current directly to the slip-ring.
7. Large slip-ring of high-current carrying ability minimizes mechanical wear and provides connection from the moving contact to the terminal.
8. Potentiometer use. The rheostats are provided with three terminals so they can be used as potentiometers or voltage dividers.
9. High strength ceramic hub insulates the shaft and bushings from all live parts. All sizes will stand a 3000 volt a-c breakdown test to ground.
10. The contact arm is a long tempered steel spring which assures uniform contact pressure at all times. Cadmium-plated for corrosion resistance.
11. Rounded pivot holds contact brush in flush-floating contact with wire.
12. Stops which are keyed to the shaft and base limit the rotation—thus no torsional strain is imposed on the contact arm on stopping.
13. Compression spring maintains uniform pressure and electrical contact between slip-ring and center lead at all times.
14. Models H, J, G, K, and L: Phosphor-bronze retaining ring takes end-thrust. Models P, N, R, T, and U: Stop washer takes end-thrust. Steel shaft in brass bushing provides a wear-resistant, wobble-free bearing.
15. Ohmite rheostats meet requirements of NEMA and EIA (formerly RETMA).
16. There are only ceramic and metal in the construction of Ohmite rheostats—there is nothing to char, burn, shrink, or deteriorate.

Write on company letterhead for Catalog 58.

BE RIGHT WITH OHMITE® QUALITY Components

OHMITE MANUFACTURING COMPANY
3618 Howard Street Skokie, Illinois

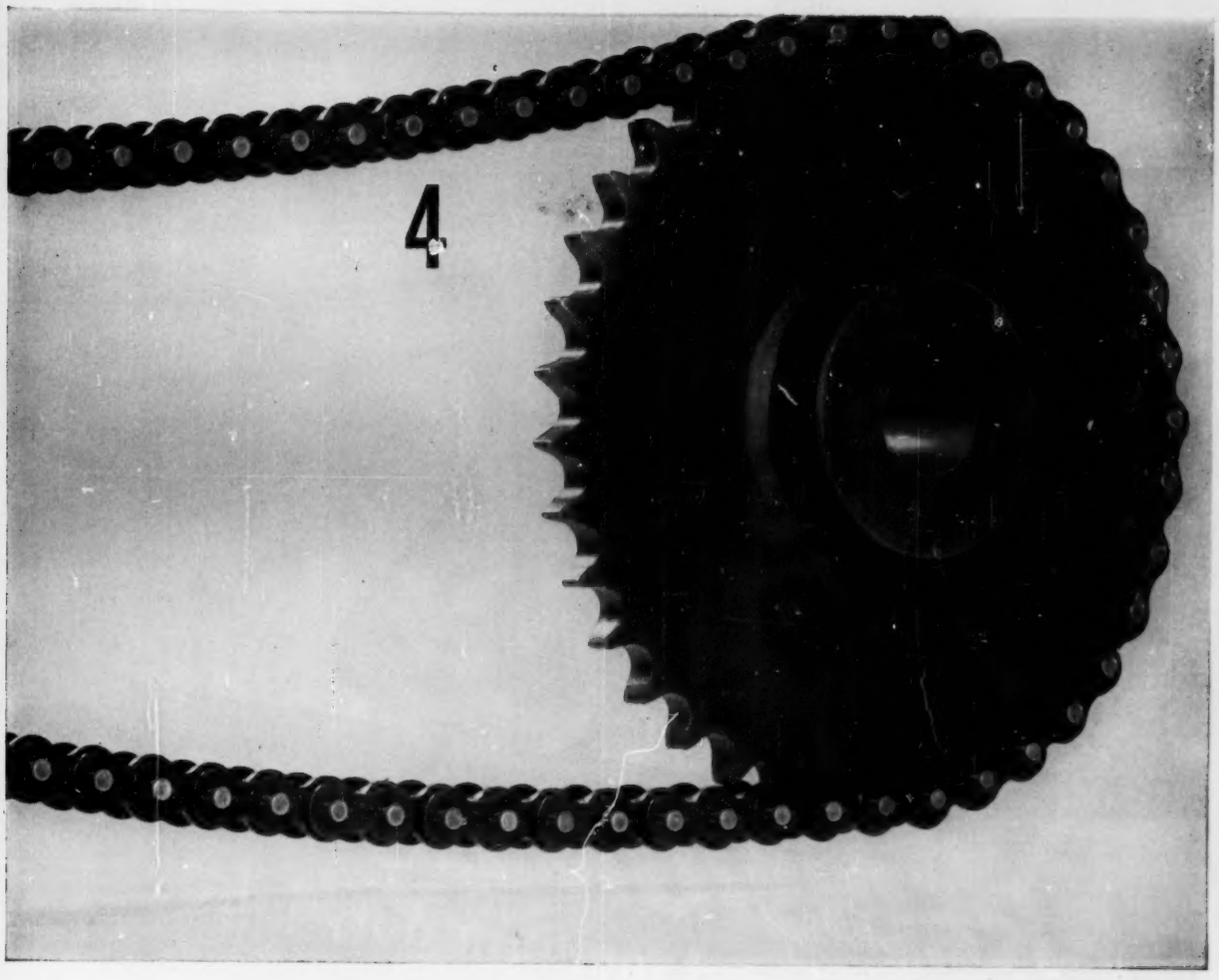
RHEOSTATS RESISTORS RELAYS
TAP SWITCHES TANTALUM CAPACITORS
R. F. CHOKES VARIABLE TRANSFORMERS



Morse's entry into the speed reducer field means:

Nobody can service your as completely as Morse, all four of these power

1 Couplings and Driveshafts	2 Eberhardt-Denver Speed Reducers	3 Clutches	4 Chain and "Timing" Belt Drives
Morflex	PoweRgear®	Torque Limiter	Roller Chain
Flexible Chain	Worm Gear	Cam	Silent Chain
Radial	Helical	Overcenter	Hy-Vo® Drives
Nylon	Gearmotors	Pullmore	"Timing"® Belt



power transmission needs because only Morse offers transmission components

REMEMBER: The toughest jobs in power transmission come to Morse, because *only Morse* offers one-source service on all four of these basic components . . . and backs them up with technical know-how based on over 60 years' experience solving power transmission problems.

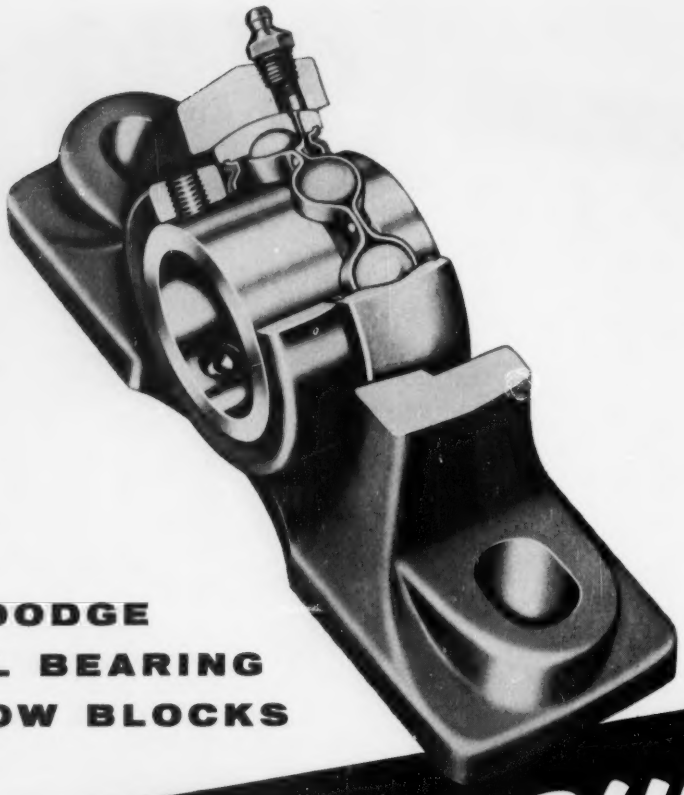
MORSE

MORSE BW

*Trademark

A BORG-WARNER INDUSTRY

MORSE CHAIN COMPANY, Dept. 6-19, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Illinois



DODGE
BALL BEARING
PILLOW BLOCKS

PRECISION BUILT
–for normal and medium duty jobs

SC

NORMAL DUTY
SHAFT SIZES—1/2" to 2-7/16"

SCM

MEDIUM DUTY
SHAFT SIZES—1-7/16" to 3-1/2"

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

- ★ High quality at moderate cost.
- ★ Deep groove ball bearing provides high radial and thrust capacity.
- ★ Long inner race distributes load over greater shaft area.
- ★ Metal backed synthetic seals are locked in position. They can't blow. Effectively exclude dust and dirt.
- ★ Completely sealed both on and off the shaft.
- ★ Fully self-aligning.
- ★ Rugged one-piece semisteel outer housing.

Pillow blocks, flange bearings, piloted flange bearings, cylindrical units, hanger bearings, screw conveyor hanger bearings.
Call your local Dodge distributor—or write us for technical bulletin.

DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Ind.

DODGE
of Mishawaka, Ind.

Circle 431 on Page 19

Circle 432 on Page 19→

ANNOUNCING

the Newest Source of Quality Stainless Sheet and Strip in the Industry

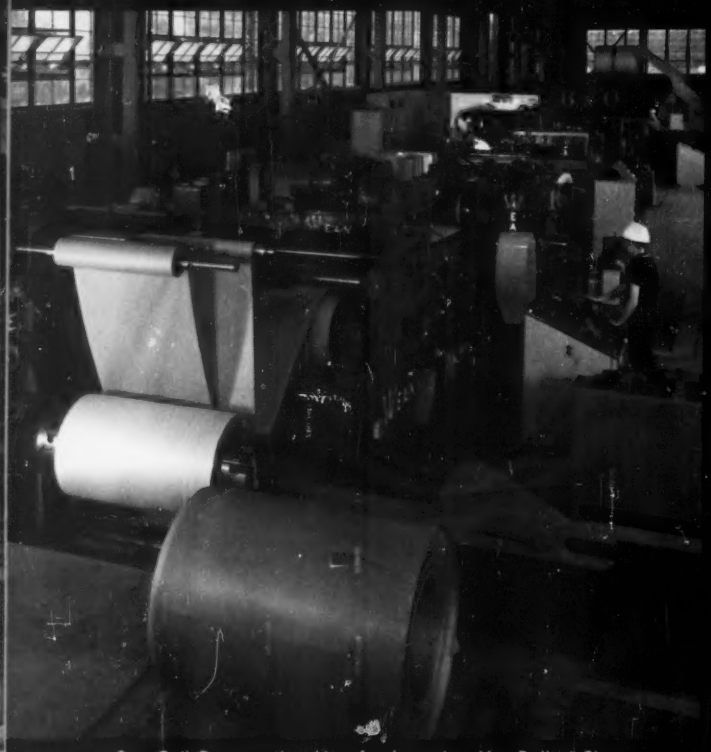
J & L's Completely New Stainless Mill . . .

designed and engineered to give you the fastest delivery on Quality Stainless Sheet and Strip

Now you can demand the quality you need and get the service you want from the most advanced stainless steel sheet and strip source in the industry. J & L's new Sendzimir Mill at Louisville, Ohio, is the result of years of planning by specialists to provide a new facility of such perfection that yield of the highest quality is assured.

J & L can now offer stainless sheet and strip to the most exacting specifications, producing stainless sheets to extremely close tolerances in widths up to 48 inches.

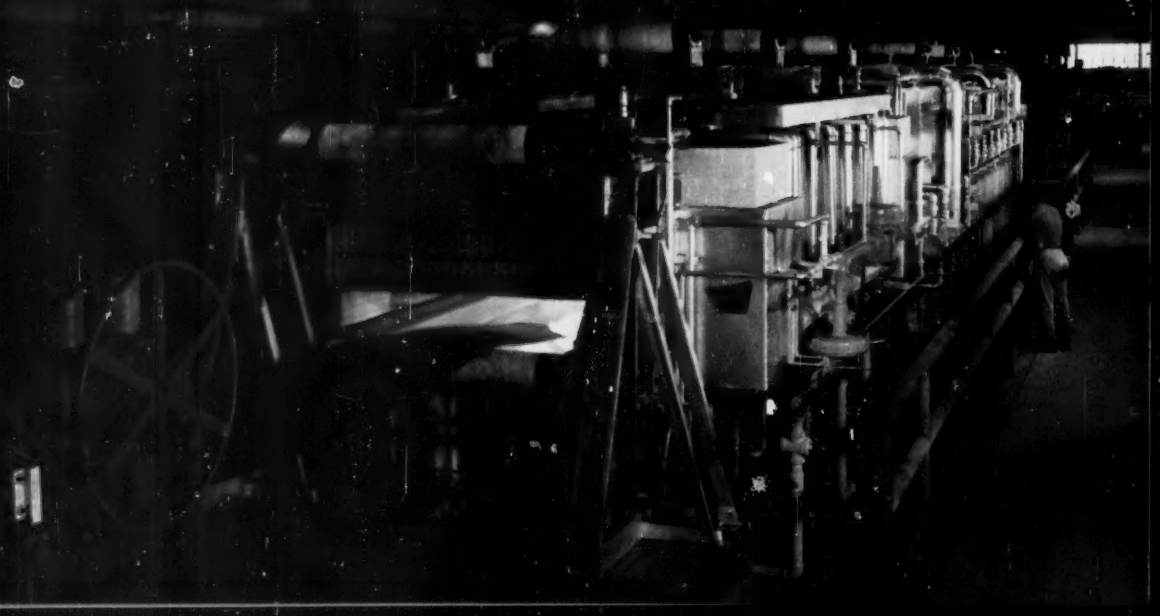
By efficient, flexible scheduling and adequate inventory support, J & L offers stainless steel buyers everywhere the fastest possible service.



▲ Coil Preparation Line for Incoming Hot Rolled Sheet

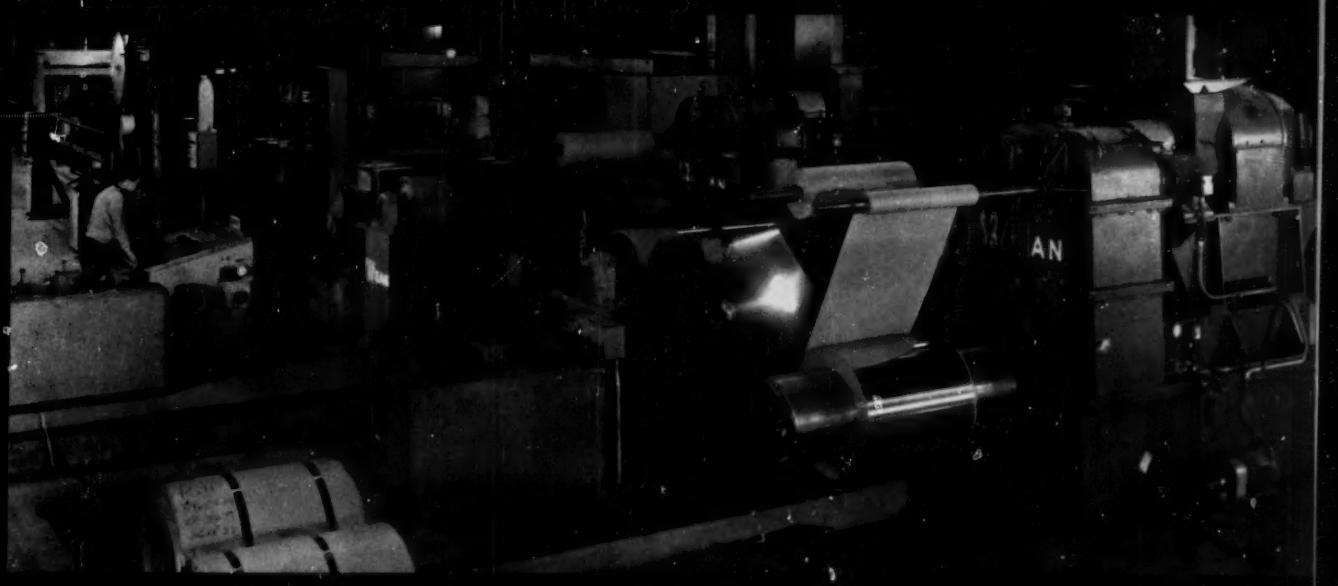
▲ The 54" Temper Mill

▼ Hot Anneal Furnace—Entry End



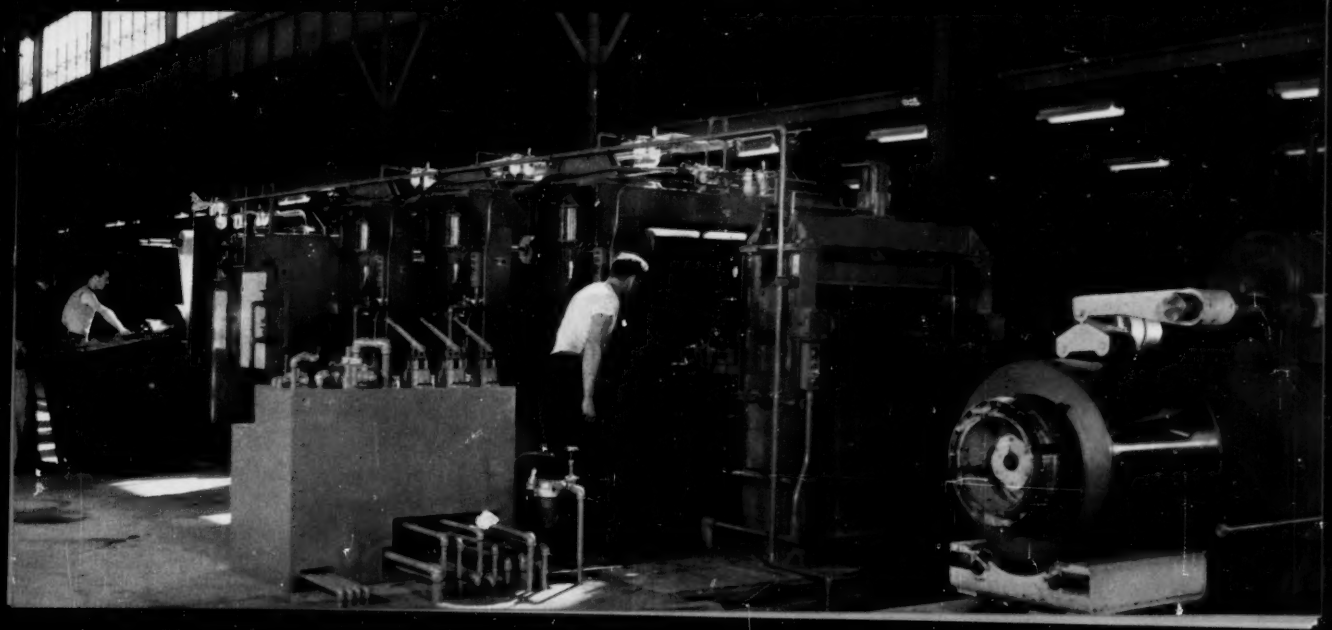
▲ The Sendzimir Mill

Interior View of the Intricate Mechanism of the Sendzimir Mill ▶

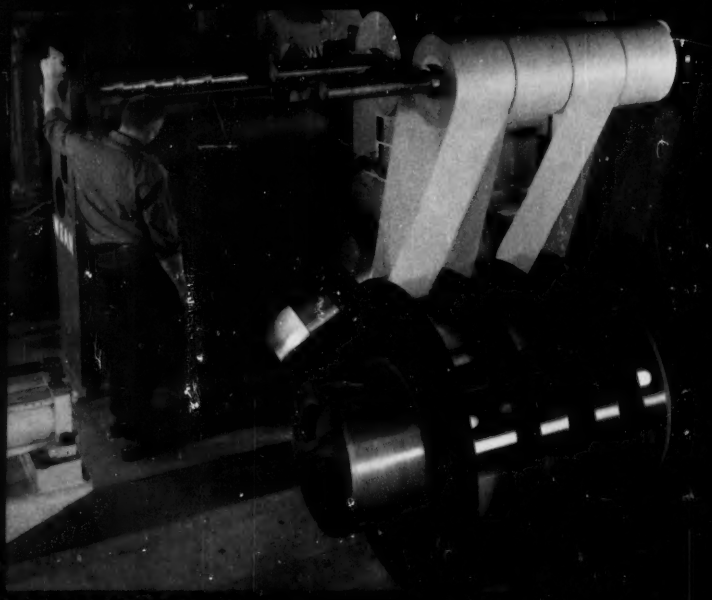


Scouring and Scrubbing Line ▼

▲ Cold Roll Anneal and Pickle Line—Discharge End



Surface Checking the 50" Slitter ▲



The 50" Slitter. One of Three Slitting Lines for Cutting Coil into Strip ▶

▼ One of the two Shear-to-Length Lines for Cutting Coils into Specified Sheet Lengths

STAINLESS and STRIP DIVISION DISTRICT SALES OFFICES

Write for your copy of the J & L Stainless Steel Sheet and Strip Manual today

CHICAGO
4010 West Madison Street
Chicago 24, Illinois

CLEVELAND
The B. F. Keith Building
1621 Euclid
Cleveland 15, Ohio

DETROIT
12301 Hubbell Avenue
Detroit 27, Michigan

EASTERN
Raymond Commerce Building
1180 Raymond Boulevard
Newark 2, New Jersey

HOUSTON
Adams Petroleum Center
6910 Fannin
Houston 25, Texas

INDIANAPOLIS
2301 South Holt Road
Indianapolis 41, Indiana

LOS ANGELES
Continental National Group Building
2975 Wilshire Boulevard
Los Angeles 5, California

J&L STEEL STAINLESS
BAR • WIRE • SHEET • STRIP

Jones & Laughlin Steel Corporation · STAINLESS and STRIP DIVISION · Box 4606, Detroit 34

LITHO USA

Typical of K-30 application is this two-piece sealing ring design with K-30 outer ring and cast iron or stainless steel inner.

Licks tough ring problems

Proven Applications

★ Non-Lubricated Compressors: air, nitrogen, oxygen, hydrogen and carbon dioxide.

★ Rotary Shaft Seals: corrosive and non-corrosive surface.

★ Miscellaneous: sealing rings wearing directly against aluminum cylinders, wear bushings, wear inserts, and plug-type pistons.

Wide Range of Sizes and Types

Koppers K-30 piston, wear and sealing rings may be made in all widths and diameters—for use with cast iron, stainless steel, aluminum or chromium-plated cylinders.

Radical, rugged Koppers K-30 gives you new operating economy and long-lived performance in applications too tough for ordinary piston and sealing ring materials. K-30, a special compound of TEFLON* with other wear-resisting materials, features:

★ *Low friction coefficient* – inhibits ring wear.

★ *Self-lubrication* – reduces cylinder wear.

★ *Zero water absorption* – means that it cannot swell or change its shape.

★ *Temperature resistance* – from a molecular structure that permits operation at temperatures from – 350° F. to 500° F.

★ *Toughness and flexibility* – eliminate breakage, scoring and other damage caused by storing, handling, installing or servicing. Permit smaller ring cross-sections and smaller piston sizes and weights.

★ *Chemical inertness* – makes K-30 corrosion-proof.

If you have a ring problem, put Koppers to work on it. Contact your nearest Koppers Representative or write KOPPERS COMPANY, INC., Piston Ring and Seal Dept., 2301 Scott St., Baltimore 3, Md.

*TEFLON—trademark of E. I. DuPont de Nemours & Co. for tetrafluoroethylene resin.

KOPPERS

INDUSTRIAL PISTON AND SEALING RINGS

Engineered Products Sold with *Service*

Circle 433 on Page 19

FOR THE MACHINERY PART

THAT TAKES THE BEATING

A cut-off knife made of HAYNES STELLITE alloy No. 19 slices through molten glass at 2200 deg. F. Despite the intense heat of the glass being molded into tumblers, and the severe erosive action of the glass on metal, the cut-off knife maintains a 0.015-in. clearance between itself and the mold ring . . . *far longer than any other material ever used.*

Are you looking for a tough metal part to improve your machinery? It will pay you to look into HAYNES alloys. There are more than 15 from which to choose, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. Parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist many conditions of wear, heat, or corrosion.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

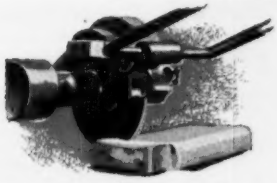
Division of Union Carbide Corporation

Kokomo, Indiana

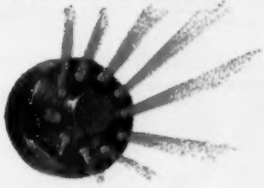
UNION CARBIDE

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS



Tough, long-lasting metal-cutting saws over 20 inches in diameter, made of HAYNES STELLITE alloy sheet, slice the tops off copper ingots.



Steam atomizer fuel burner nozzles of HASTELLOY alloy C resist corrosive agents and erosion for months, retaining essential contours.

High-temperature strength and corrosion resistance of diesel combustion chambers made of HASTELLOY alloy C make them "good for life of the engines."

Circle 434 on Page 19

Table-top operation . . .

and full 42-inch width . . .

. . . combined in one Whiteprinter

OZALID
Streamliner 200

Now all the advantages of whiteprinting are combined in a convenient TABLE MODEL—the new, low-cost Ozalid Streamliner 200.

Compact, easy to operate, the Streamliner 200 stands just 22″ high, 38″ deep (including feedboard). With it *anyone* can turn out sparkling whiteprints in seconds *up to 42 inches in width!*

Perfect for the small office, it's an ideal stand-by for the large printroom, too. For the full story call your local Ozalid representative or write Ozalid, Dept. S-1-9, Johnson City, N. J.

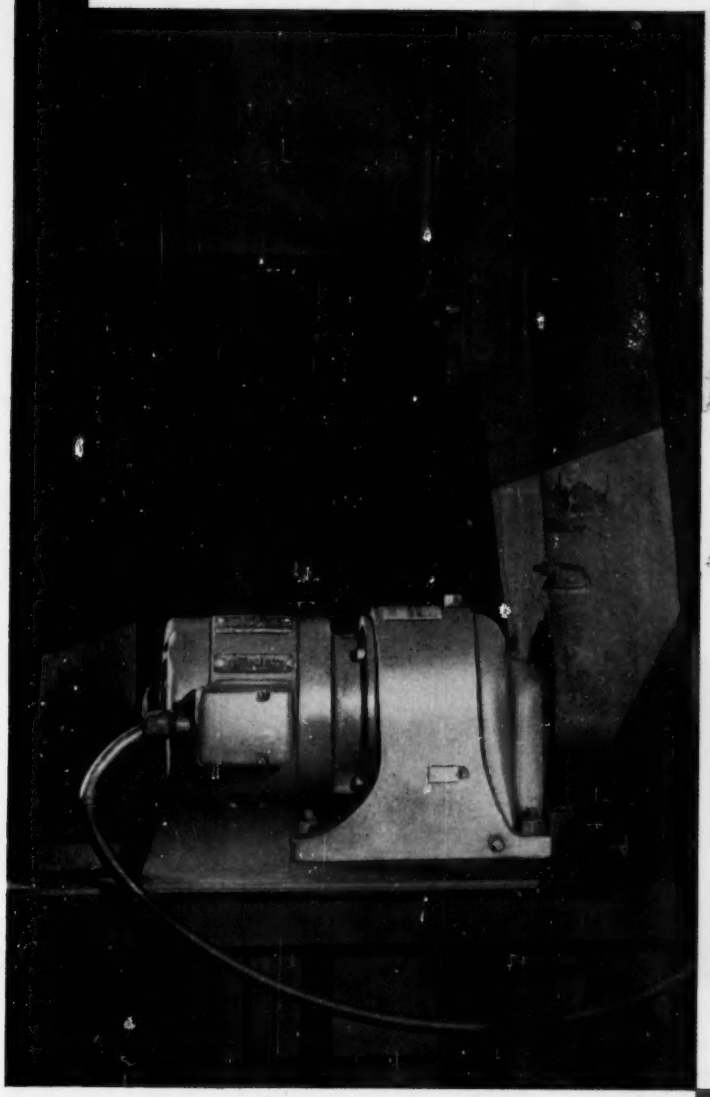
OZALID®

First Name in Whiteprinting

A Division of General Aniline & Film Corporation. In Canada: Hughes Owens Company, Ltd., Montreal.

Circle 435 on Page 19

Tight space? Perfect place for a Link-Belt Gearmotor



Maintains life-long alignment with flange-mounted NEMA motors

Here's a speed reducer right in step with industry's campaign for higher productivity in less space. Because its gear trains incorporate a minimum of parts . . . because its motor is directly connected to the gear drive with a flange—the Link-Belt Gearmotor is the ultimate in compactness.

Imagine how these same features cut costs. The flange connection eliminates additional coupling devices. Simple gear trains have fewer parts to wear, to service, to invite trouble.

You'll find them in Book 2747. Call your nearby Link-Belt office.

LINK-BELT

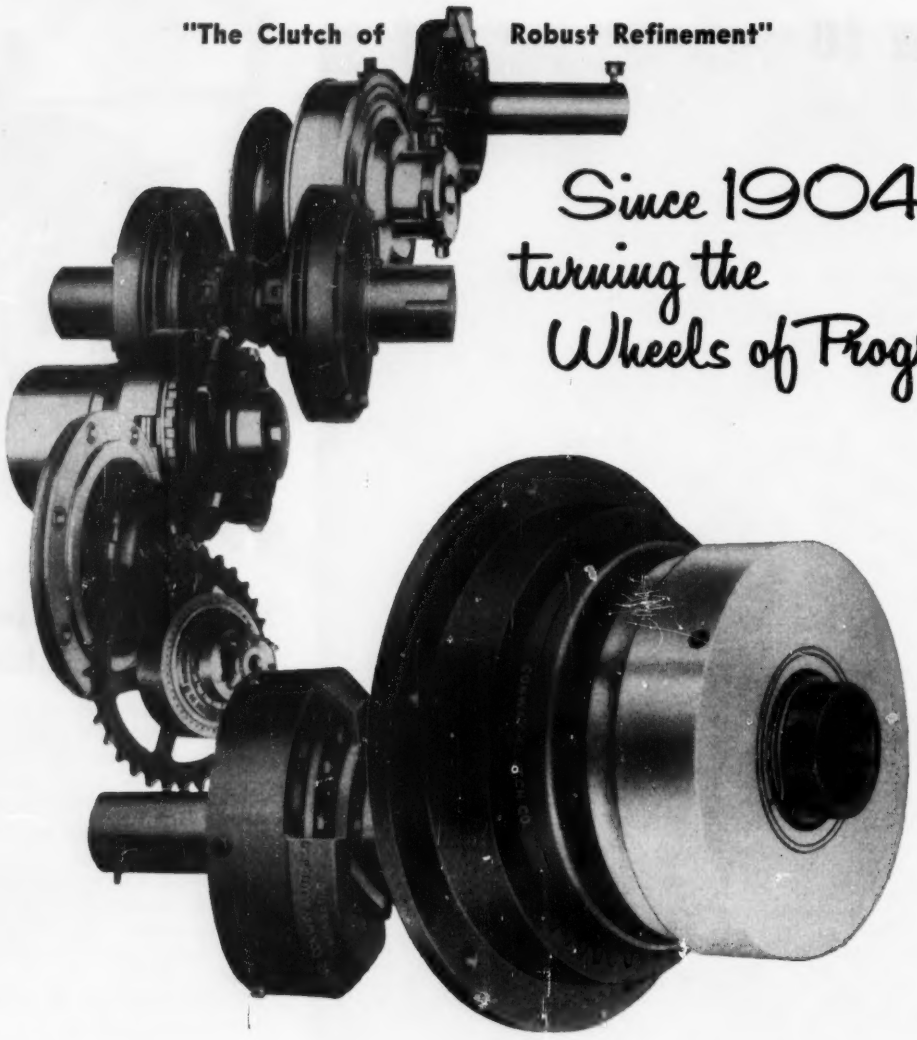
SPEED REDUCERS

LINK-BELT MOTOGEAR—for bracket-mounting all makes and enclosures of foot-type NEMA motors — simplifies motor replacement. Sizes to 100 hp.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,806-A

CONWAY CLUTCHES

"The Clutch of Robust Refinement"



Since 1904 turning the Wheels of Progress

SINCE the turn of the century Conway progress has kept pace with or ahead of progress in industry . . . often foreseeing problems and providing practical solutions to insure

ECONOMICAL TRANSMISSION OF POWER

This policy is inherent in the Conway ideal of service in design, engineering and skilled craftsmanship.

• *Write us for help on power transmission information.*

THE CONWAY CLUTCH COMPANY

2750 Colerain Ave. Cincinnati 25, Ohio

The World's Most Respected Name in Industrial Clutches for more than a half-century.

How to squeeze more production from your automatic forging equipment

...at no extra cost

AUTOMATIC forging machines are no better than the uniformity of the steel you process. When structural or chemical changes occur in the steel you're using you have to interrupt operations to adjust your equipment. And you lose the continuous production you paid for!

You can avoid these interruptions by using uniform steel. Timken® electric furnace fine alloy steel, for instance. It's uniform from bar to bar, heat to heat, order to order.

We take many extra quality-control steps to make sure it's uniform—many of them were American steel industry "firsts". For example, our magnetic stirrer for molten steel assures equal distribution of alloys, uniform temperature and working of the slag. A direct-reading spectrometer insures exactly correct composition to the very moment a heat is tapped. And individual order-handling assures uniformity that meets your own end-use requirements.

You'll squeeze the most production from your automatic forging equipment, at no extra cost, by specifying Timken fine alloy steel. You'll get uniform steel and faster, continuous production. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

HOW THE ENGINEERING SERVICES OF

Central Foundry

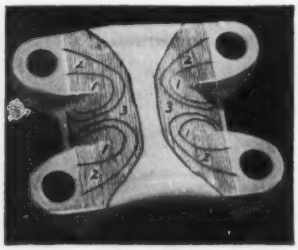
help you design better castings at lower cost

Many new developments here at Central Foundry have broadened the field of application for castings and have given design engineers greater latitude. To assist you in exploiting these new methods and materials to fullest advantage, each of our engineering departments—design, experimental, process and metallurgy—is at your disposal. Central Foundry is also using a number of testing techniques such as stress analysis, cobalt radiography and sonic testing, that have proven invaluable in lowering the cost and improving the quality of castings. These procedures help us to determine the best design and method of producing a casting, either by the green sand method or the shell mold process, and the best material for the casting, either grey iron, malleable iron or ArmaSteel.

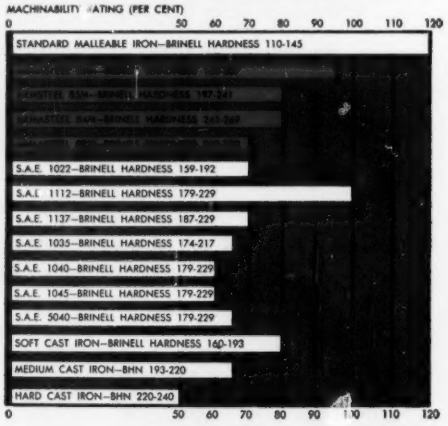
Central Foundry has the capacity to deliver, on schedule, quality castings in production quantities.

STRESS ANALYSIS FOR IMPROVED DESIGN

An important part of our engineering services is the stress analysis laboratory. Stress analysis discovers the amount of stress on a part due to its service function and is an important aid in determining and improving the strength of a part. Improved casting design can be accomplished through the use of stress-analysis by more effectively distributing the metal in the part. The U-bolt anchor plate shown here is a case in point. Our customer was experiencing failures in this part and asked us to see what we could do to solve the problem. Using stress analysis the part was completely redesigned for maximum efficiency. The redesigned part is 35% stronger, 42% lighter and less costly.



EXCELLENT MACHINABILITY FOR INCREASED PRODUCTION


MACHINABILITY RATING (PER CENT)
0 50 60 70 80 90 100 110 120
STANDARD MALLEABLE IRON—BRINELL HARDNESS 110-145
S.A.E. 1022—BRINELL HARDNESS 159-192
S.A.E. 1112—BRINELL HARDNESS 179-229
S.A.E. 1137—BRINELL HARDNESS 187-229
S.A.E. 1035—BRINELL HARDNESS 174-217
S.A.E. 1040—BRINELL HARDNESS 179-229
S.A.E. 1045—BRINELL HARDNESS 179-229
S.A.E. 5040—BRINELL HARDNESS 179-229
SOFT CAST IRON—BRINELL HARDNESS 160-193
MEDIUM CAST IRON—BHN 193-220
HARD CAST IRON—BHN 220-240
0 50 60 70 80 90 110 110 120

CENTRAL FOUNDRY DIVISION

REDESIGN FOR STRENGTH

This is a rear spring clip pad that was converted to a casting with the help of stress analysis. The clip pad supports the shock absorber arm and clamps the spring to the rear axle of an automobile. When produced as a stamping, this part weighed 4-1/4 pounds. However, when designed as an ArmaSteel casting, weight was reduced to 2-9/10 pounds. Most important, based on comparative stress analysis tests, the casting is *30% stronger* than the stamping. (In addition, the holes are produced by the foundry, making it unnecessary for the customer to punch them.) This conversion from a stamping to a casting resulted not only in increased strength, but in substantial cost savings, as well.

REDESIGN FOR IMPROVED PRODUCT AND ECONOMY

Many of our customers have found that redesigning a product to be made as an ArmaSteel casting rather than as a fabrication, forging or stamping, has resulted in a better part at less cost. The fabricated design of a rear wheel truck hub at the left consists of a forged base with a steel plate welded in place to form the smaller flange. The casting on the right, designed jointly by the customer and our engineers, is of single piece construction, is lighter, stronger and less costly than the fabricated design and eliminates the fitting and welding of the small flange.

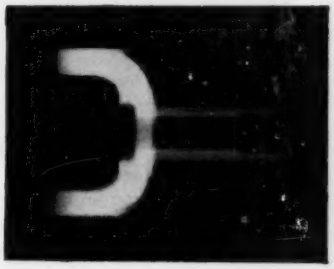
FABRICATED DESIGN ARMASTEEL CASTING

PROCESS ENGINEERING FOR LOWER COST

Our process engineers are continually looking for ways to more economically produce castings, thus lowering the finished-product cost. Shown here is a single casting that combines 5 bearing caps used on a V-8 engine. The casting is almost completely machined as a single piece, and the parts are then separated in a final operation. Substantial savings are realized in both casting and machining costs.

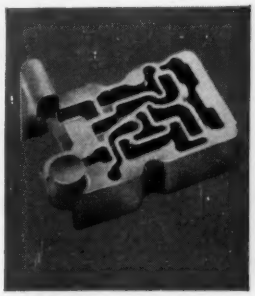
COBALT RADIOGRAPHY FOR ASSURED QUALITY

Radiography, by means of Cobalt 60, has drastically reduced the time required to check castings and is an important aid in obtaining the best possible casting quality. In an effort to eliminate a machining operation on the universal joint yoke shown here, a design change was made in the tube section of the part. When sample castings of the new design were checked radiographically, it was immediately apparent that the design was unsatisfactory since it caused acute metal feeding problems. By redesigning and further checking by radiography, Central Foundry was able to produce, in the shortest possible time, a lighter casting which required less machining in our customer's plant.



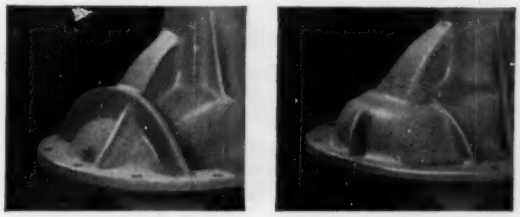
SHELL MOLDING FOR GREATER ACCURACY

Shell molding, a relatively new process of making castings, is now being employed extensively for fast, simple production of complicated castings, such as those requiring narrow, accurate passages and cross sections. It is practically impossible to produce certain parts in any other way without prohibitive costs; this is especially true of ferrous metals. Complicated parts like the manual control valve body shown here, a part of the automatic transmission of a military vehicle, are readily cast in grey iron when the shell process is utilized. The part had been considered as an aluminum die casting, but was thought unsatisfactory because of adverse expansion and wear characteristics. In this case, meeting the requirements for very close tolerances on the thickness and location of ports was made possible by the shell molding process.



REDESIGN FOR WEIGHT REDUCTION

Vehicle weight reduction is a matter of increasing importance to design engineers . . . and more and more existing parts are being converted from a low or medium to a high strength ferrous material such as ArmaSteel. On the left is a grey iron differential carrier currently used in an automobile. By taking advantage of the superior physical properties of ArmaSteel, it was possible to design the part on the right which is *five pounds lighter*. The modulus of elasticity of ArmaSteel is approximately 60% greater (the tensile strength about twice as great) than the grey iron material.

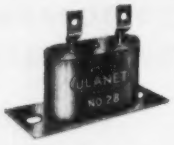


90

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

YOU CAN PROFIT BY USING GENERAL PLATE CLAD METALS

Ulanet Thermostats Value Continued Material Uniformity in TRUFLEX parts and assemblies



Model 28 Miniature Hermetically Sealed Thermostat extremely sensitive.

Here's another case history of a leading manufacturer who has found he can depend on parts made from General Plate's TRUFLEX thermostat metal. H. Ulanet, President of the George Ulanet Company, puts it this way:

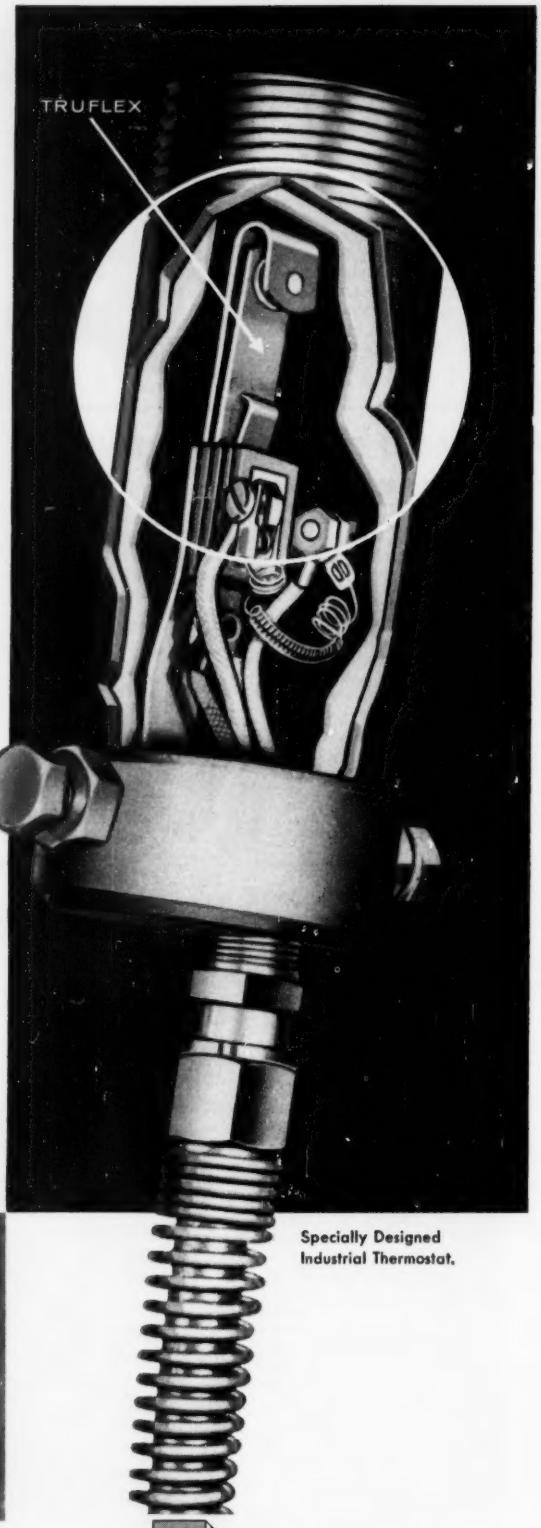
"Bimetal is a most important component in Ulanet Thermostats which have a world-wide reputation for quality. Therefore we must be certain of continued material uniformity and quality with each shipment.

"During our 22 years' experience with General Plate's TRUFLEX *thermostat metals we have found that they have met our exacting specifications."*

General Plate can supply dependable thermostat metal parts and assemblies for installation in your products, too. You'll get top performance because the high quality of each piece you receive is consistently uniform — an exact duplicate of the original.

General Plate TRUFLEX thermostat metal parts and assemblies are made to meet your specific needs for temperature range, electrical conductivity and corrosion resistance.

If you set up to make your own parts, General Plate can supply TRUFLEX thermostat metal strip to consistently meet your specifications. Send us your specifications for parts or strip — we'll be pleased to quote.



Specially Designed Industrial Thermostat.

A few typical Truflex formed parts and sub-assemblies.

You can profit by using General Plate Clad Metals!

METALS & CONTROLS CORPORATION

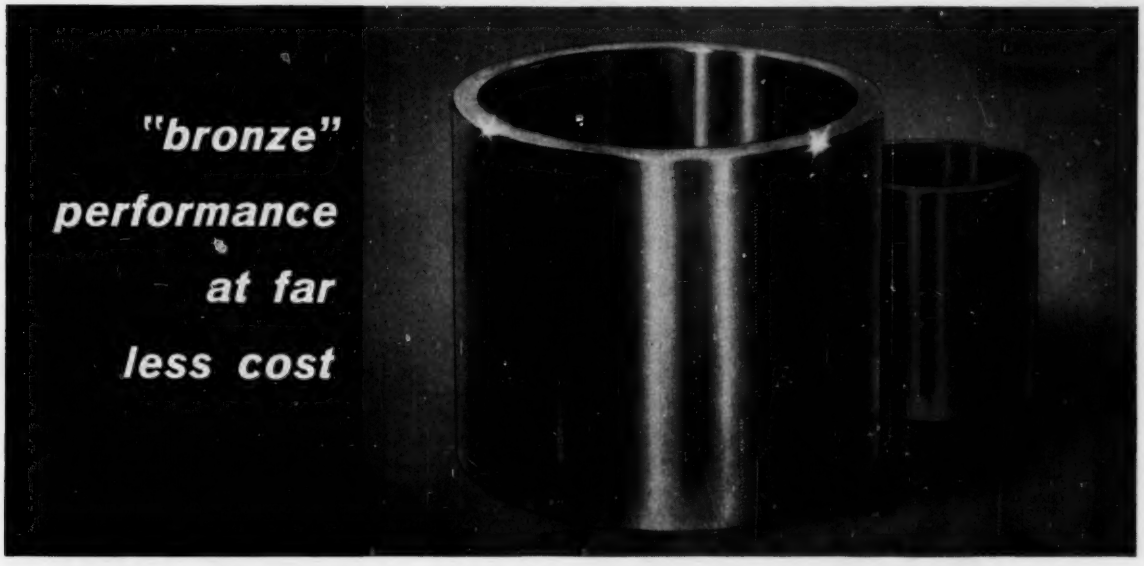
General Plate Division

801 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK • CHICAGO • DETROIT • INDIANAPOLIS • MILWAUKEE • PASADENA

Circle 440 on Page 19

introducing NEW IRON OILITE 212 BEARINGS



The important difference between the porous bronze bearing (right) and the all-new Iron OILITE* 212 Bearing (left) is cost. While both bearings give long, maintenance-free service, Iron Oilite 212 bearings now open the door to major savings for many equipment manufacturers.

Performance-proved in life tests and on actual products, Iron Oilite 212 bearings have a service life equal to porous bronze when used for products where corrosion is not a problem and mechanical strength requirements are within tolerable limits.

A high oil content — approximately 20% by volume — assures adequate lubrication for the lifetime of many end products. In addition, a unique built-in service factor gives Iron Oilite 212 bearings extraordinary protection against temporary overloads. They perform best when carrying medium to heavy loads at relatively low speeds and readily equal the performance of bronze at the high speeds required by home appliances, fractional horsepower motors, power tools, light machinery and other products.

It's another Amplex first . . . a typical example of how Amplex serves a growing number of original equipment manufacturers with "better quality at lowest cost". Use Amplex's extensive research and engineering facilities to your own advantage. Savings can be impressive if you require bearings in volume.

free sample

of IRON OILITE 212 Bearing 1" ID x 1¼" OD x 1" Length and full information on request. Consult the Oilite engineer in your area. Find him in the Yellow Pages under "bearings" or write direct to Amplex. Address Dept. S-1

COMPARISON OF TYPICAL PHYSICAL PROPERTIES

	Iron Oilite 212	Oilite Bronze
Porosity, % oil by volume	18 - 23	18 - 23
Ultimate Tensile Strength, (psi)	10,000	18,000
Compressive Yield Point, (psi)	9,500	20,000
Rockwell Hardness	RH - 35	RE - 65
Specific Gravity	6.1 - 6.5	6.4 - 6.7

* REGISTERED TRADEMARK
ONLY CHRYSLER MAKES OILITE

SINCE 1929 — A CHRYSLER OILITE PRODUCT

the most trusted name in powder metallurgy!

AMPLEX DIVISION

CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

SELF-LUBRICATING BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

B.F.Goodrich

Lawn Boy cuts cost of fuel tank assembly with B. F. Goodrich Rivnuts®

When Lawn Boy designed their current power mower models, they decided to *suspend* the fuel tank underneath the streamlined shroud. But in order to do this they needed specialized fasteners that would fit inside the tank and provide shock-proof, fuel-tight nutplates.

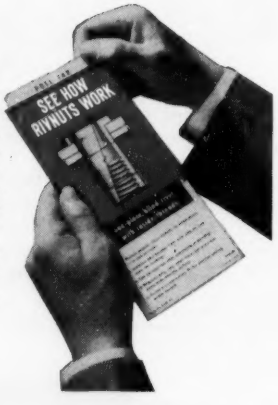
They found that B. F. Goodrich Rivnuts would do this job better and more economically than any other fastener. Here's how. After the tank is formed, two holes are punched in its top. One man takes only a few seconds to upset Rivnuts in these holes. Screws are then inserted through the shroud and into the Rivnuts, attaching the tank solidly.

B.F.Goodrich Rivnuts provide firm nutplates that won't vibrate loose during operation of the mower. In addition, the special closed ends and tight clinching action of Rivnuts form a 100% fuel-tight seal.

Rivnuts can be used hundreds of ways to simplify production—give your products more eye-appeal, more sales-appeal! If you haven't already investigated their potential in your own business, why not do it now?

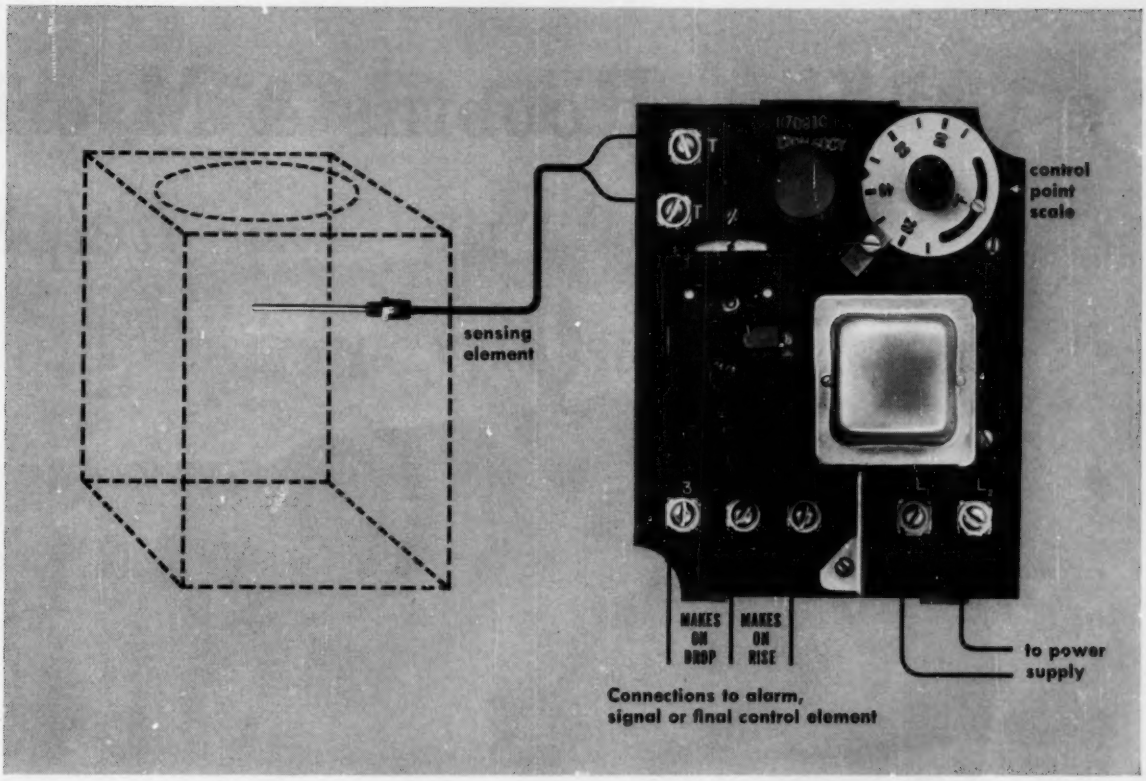
Send today for free Rivnut Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept.* **MD-19,** *Akron, Ohio.*



B.F.Goodrich *aviation products*

Circle 442 on Page 19



Now . . . precise, low-cost temperature control . . . with new VERSA-TRAN®

VERSA-TRAN is an exciting new development in low-cost controls—an entirely different kind of amplifier relay that works with specially designed sensors to control temperature with the accuracy usually found only in more complex instruments.

VERSA-TRAN relays are fully transistorized, vibration resistant, and designed for long, dependable service in even the most demanding applications. They control liquid or air temperatures in overlapping ranges from –60° to 500° F, and surface temperatures from –60° to 200° F.

Wiring between the relay and the sensor can be ordinary 18 gauge, 2-conductor cable. The relay is available for flush mounting, surface mounting, or for mounting in most electrical enclosures. It has been accepted for UL listing. VERSA-TRAN gives you flexibility and sensitivity at surprisingly low cost . . . is already solving many difficult control problems.

Your nearby Honeywell field engineer can help you profitably apply new VERSA-TRAN transistorized controls. Call him today . . . he's as near as your phone.

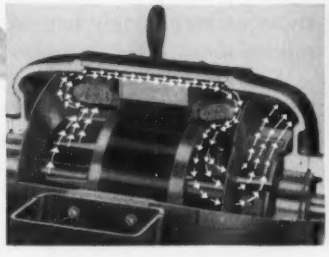
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

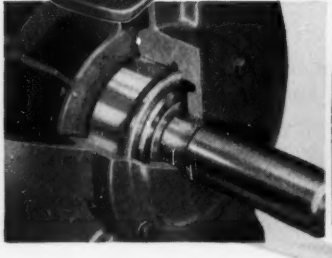
Honeywell

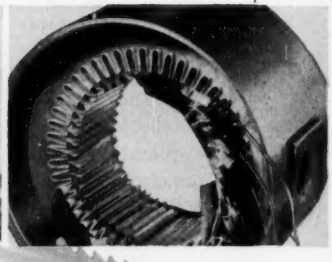
First in Control

Robbins & Myers

helps







Highly efficient dual-sweep ventilation

Tandem fans, one pushing and one pulling, cool motor from end to end . . . air-wash field coil ends . . . eliminate "hot spots" . . . greatly prolong motor life!

Fully sealed prelubricated bearings

Run in double-width races . . . have extra-large lubricant reservoirs . . . seldom need re-lubrication . . . are quickly, easily inspected by removing cover plates!

Life-prolonging *Mylar insulation

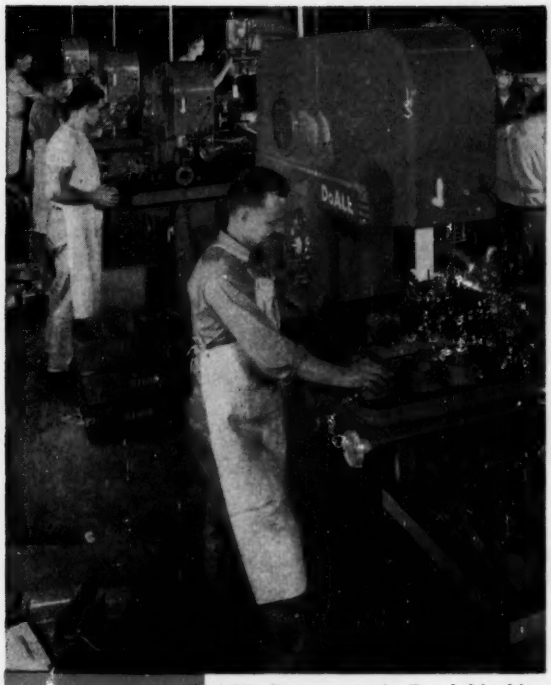
Has excellent dielectric qualities . . . resists tearing and aging . . . assures virtually permanent protection. Rag paper backing cushions against abrasions and punctures!

* DuPont registered trademark

MOTOR STAMINA

DoALL machines

saw their way to success!



DoALL Contour-matic Band Machine

The DoALL Company equips its versatile Power Saws and Contour-matic Band Machines with sturdy, dependable R&M motors. These motors are precision-built, with ample reserve power that helps DoALL achieve record-breaking cutting rates while working at greater feed and speed pressures.

In thousands of DoALL-equipped plants, R&M motor stamina has proven itself. R&M motors take toughest DoALL jobs in stride—powering their new Demon high-speed steel cutting tool in the machining of harder-to-cut tough new alloys. DoALL versatility depends on reliable power to saw, file, grind or polish all materials. The same strong R&M motor also drives the machine's hydraulic and air pumps, providing smooth power for automatic stock feeding, work table positioning, etc.

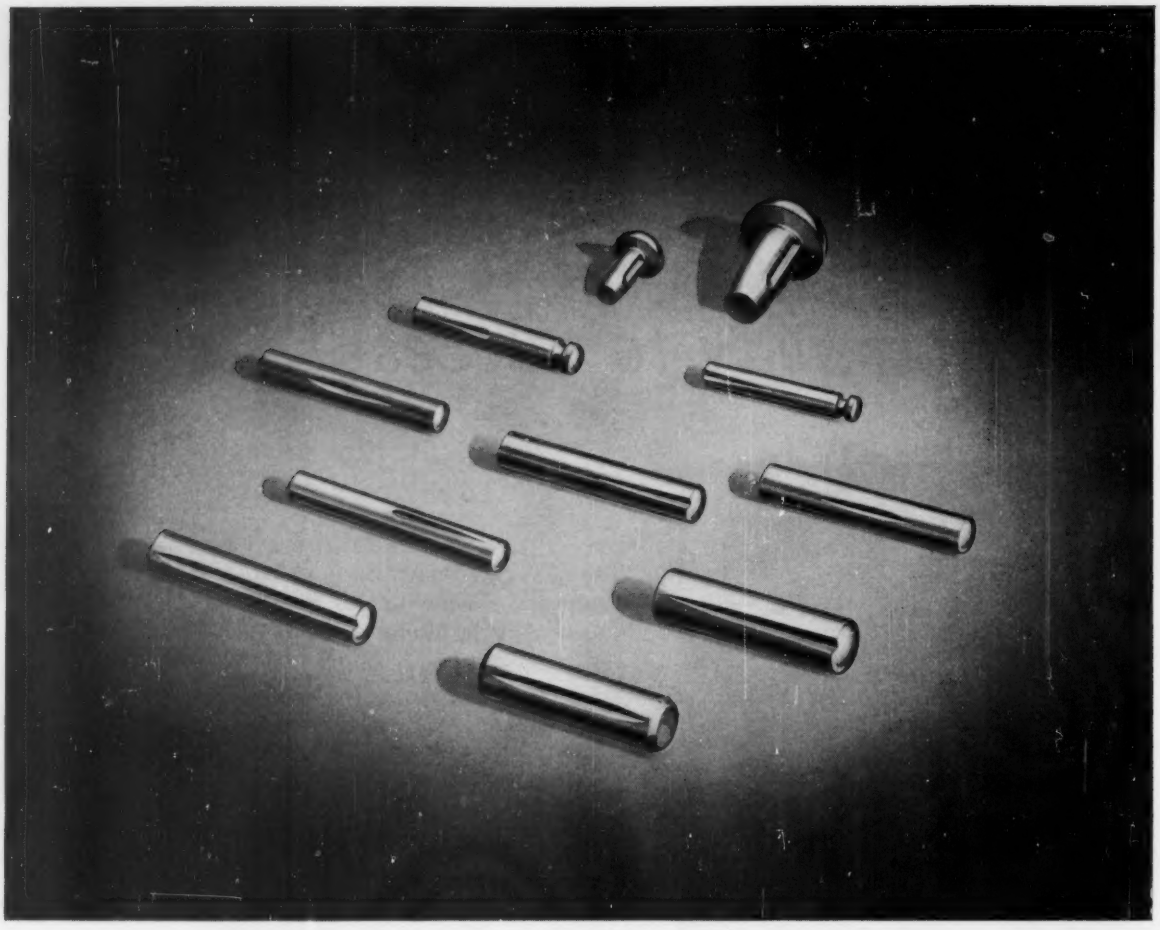
If your product requires heavy duty motors designed for faster, more versatile production, plus top dependability, Robbins & Myers can help you.

Contact your R&M representative or write today for Bulletin 520-MD

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

R&M builds motors from 1/200 to 200 horsepower

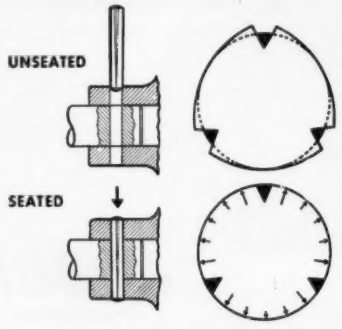


The surest, safest way ever developed to pin two parts together...

THE SOLID GROOV-PIN

Just drill the hole and drive the Groov-Pin home . . . once seated, it stays there, no matter what the conditions of shock and vibration. Yet it can be drifted out and reused with but little loss of its original holding power. No reaming is necessary. Available in nine different types, as well as in drive studs. Diameters from 1/32" to 1/2" and larger for special requirements, in a wide variety of materials. There's a Groov-Pin for every need, including the Type 3H for hopper feeding, and Types 6 and 7 for anchoring tension springs. Standard prices apply to specials in lots of 5000 or more.

Write today for free samples and the new 32-page Groov-Pin catalog... yours for the asking, it belongs in every designer's file of fastener reference literature. Address Groov-Pin Corporation, 1130 Hendricks Causeway, Ridgefield, N. J.



The unique GROOV-PIN locking principle

When a Groov-Pin is driven, the material displaced by the grooves is forced to flow back, setting up a powerful locking force. The ability of Groov-Pin to hold under severe shock and vibration . . . and its immunity to vibration fatigue . . . has been thoroughly proved by the billions in use!

GROOV-PIN

Circle 445 on Page 19

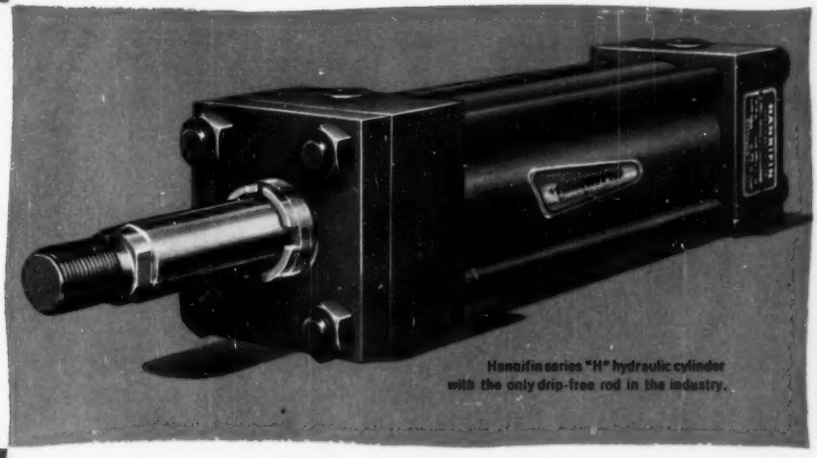
Circle 446 on Page 19→

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

Bronze cartridge gland with "LIPSEAL"® and "WIPERSEAL" can be easily replaced without dismantling cylinder.

HANNIFIN

hydraulic cylinders proved best by drip-free test



Hannifin series "H" hydraulic cylinder with the only drip-free rod in the industry.

Select either "Step-Seal" piston rings (standard) for most applications or exclusive "LIPSEALS" where zero "clearance flow" is required.

No oil dripping on machine, product or floor proves complete sealing of oil within the cylinder by our removable, replaceable bronze cartridge gland with the exclusive "LIPSEAL"® and "WIPERSEAL" combination. (This new-type gland is shown close up at upper left.) This gland not only seals better, its long bearing surface is inside the seals where lubrication is assured.

Other Hannifin cylinder features include ground and polished rods hardened to an extra-deep case, then hard-chrome plated and polished again; cylinder walls "Tru-Bored" straight and perfectly round *before* being honed... PLUS 48-hour delivery on most standard Hannifin cylinders whenever required.

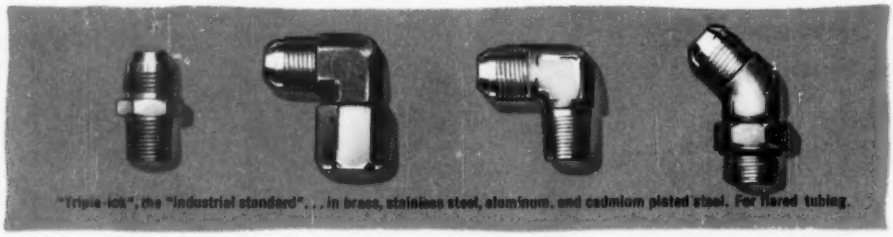
Your nearest Hannifin sales office or representative is listed in the A-Z volume of Thomas' Register. Call us in when cylinders figure in your designs. Or, for cylinder literature, write:

HANNIFIN COMPANY

515 South Wolf Road • Des Plaines, Illinois

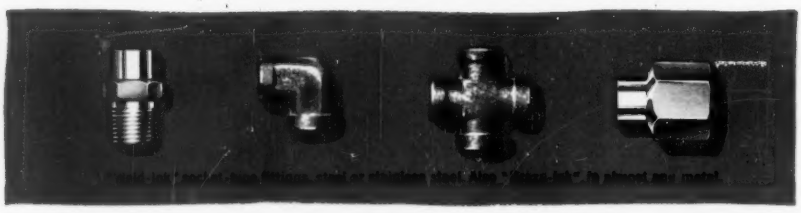
A DIVISION OF PARKER-HANNIFIN CORPORATION

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

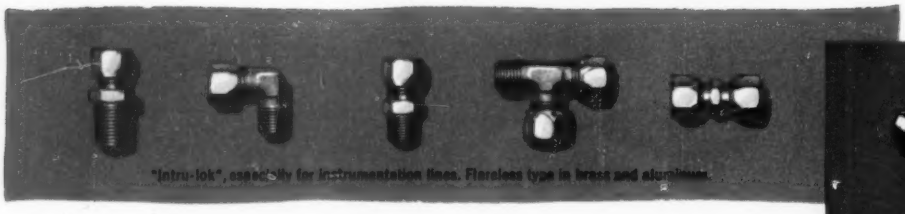


"Triple-lok", the "industrial standard"... in brass, stainless steel, aluminum, and cadmium plated steel. For flared tubing.

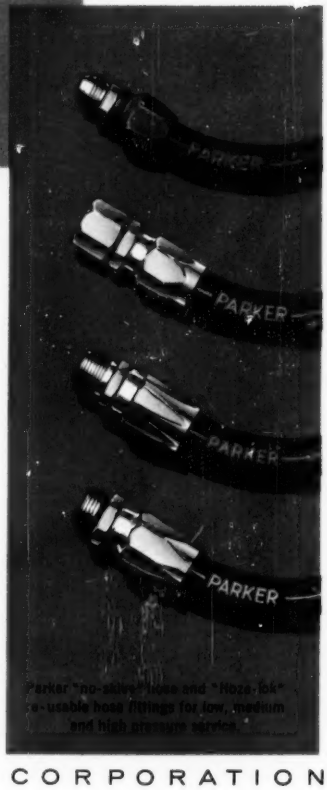
"Ferulok"®, the flareless type with the visible "bite", especially for heavy-wall tubing... in steel and stainless steel.



"Weld-lok" socket-type fittings, steel or stainless steel. Also "Braze-lok", in almost any metal.



"Intru-lok", especially for instrumentation lines. Flareless type in brass and aluminum.



Parker "no-skive" hose and "Hoze-lok" re-usable hose fittings for low, medium and high pressure service.

Only from Parker

such a wide range of fittings...so fast

If it's an industrial fitting, whether for tubing or for hose, Parker has it or can make it, in standard sizes in any metal.

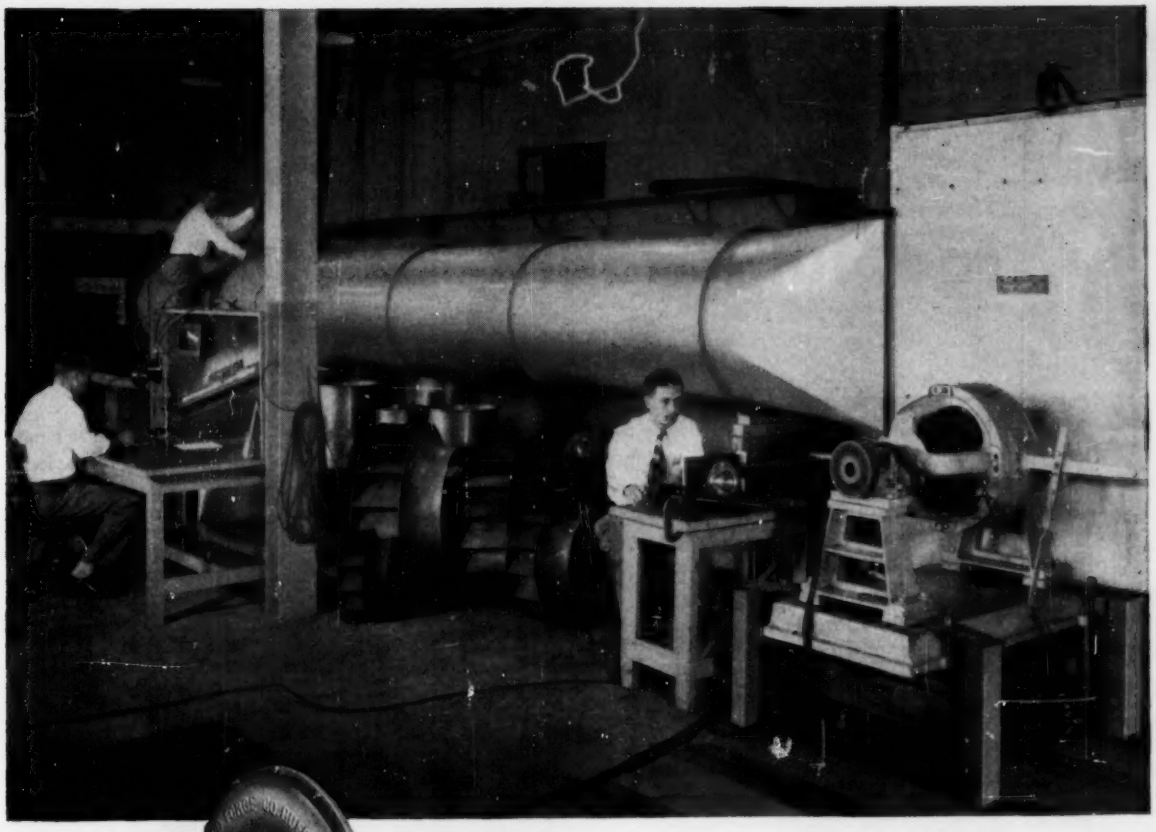
Parker "Triple-lok" for flared tubing . . . Parker "Ferulok"® for heavy-wall tubing . . . Parker "Weld-lok" for high-temperature, high pressure lines. ("Braze-lok", our newest line, does not require an open torch, is for medium temperatures.) "Intru-lok", for copper, aluminum or plastic instrumentation lines, requires no flaring. Parker hose and "Hoze-lok" re-usable hose fittings require no skiving of the hose.

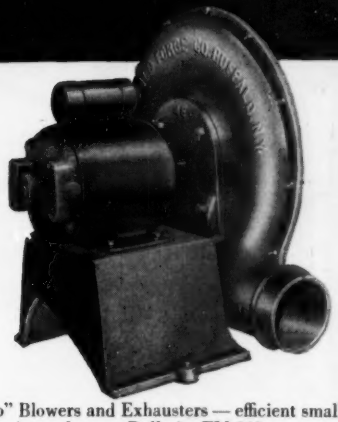
There's a Parker distributor near you, write us for his name . . . call him for Parker catalogs.

Parker Fittings and Hose Division

17325 Euclid Avenue • Cleveland 12, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION





"Buffalo" Blowers and Exhausters — efficient small units for a variety of uses. Bulletin FM-900.

Special design propeller fan — custom built for specific installation.

THE "BUFFALO" FAN YOU BUY HAS PROVEN ITS ABILITY!

When you select a "Buffalo" fan as a part of your product, you are assured of rated performance.

If you specify a standard unit, you know the design has been tested and rated, and tables are available for you to select the exact air movement required.

If you have special conditions to be met, "Buffalo" will design and test the fan for performance. Here is what one customer had to say: "Our engineers express appreciation for the very fine job you did — predictions for air delivery and noise levels were highly accurate."

The next time you want an air handling unit of proven performance, call your nearest "Buffalo" Engineering representative. Or write direct to the factory for recommendations on your particular requirements.

BUFFALO FORGE COMPANY
Buffalo, New York

Buffalo Pumps Division, Buffalo, N. Y.
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo"

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

←Circle 447 on Page 19

Circle 448 on Page 19

ELECTRONIC and ULTRASONIC quality control of MUELLER rod, tube, fabricated parts and

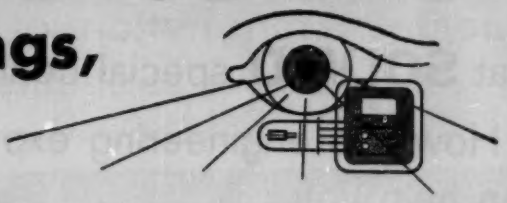
Every practical electro-mechanical testing device available to industry today is used by the Mueller Brass Co. to maintain Positive Quality Control during each manufacturing operation. From the first stages of alloying, spectroscopic analysis is used to maintain exact alloy composition so that they are precisely as specified. Ultrasonic test equipment is utilized in the non-destructive testing of extruded brass and bronze rod, copper tube, forgings and fabricated parts. In machining and finishing operations, statistical quality control is employed to eliminate the effect of possible human error. These quality controls are all designed for one purpose . . . to give you complete "product protection."

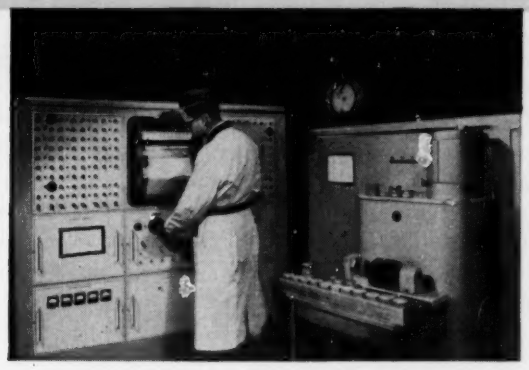
•

Copper base alloy rod is examined by a trained operator with the aid of an ultrasonic reflectoscope. Through electronic circuitry, ultrasonic echoes are translated on a cathode ray tube. Any internal flaws are readily apparent. Both rod and tube are tested by this method, which is just one of many Positive Quality Control checks used by the Mueller Brass Co.

Through ultrasonics, the immerscope (Left) locates internal defects, and has exceptional versatility for examining intricately shaped parts, such as the forging being checked in this photo. When testing, a transducer, located at the bottom end of the search tube, is electronically actuated to produce from 2.2 to 25 million cycles per second. Ultrasonic echoes are reflected back to the transducer from the material, indicating any defects that may be present. Limits may be pre-established and the sound findings are visually recorded on the cathode tube. This is another instance of Positive Quality Control in action.

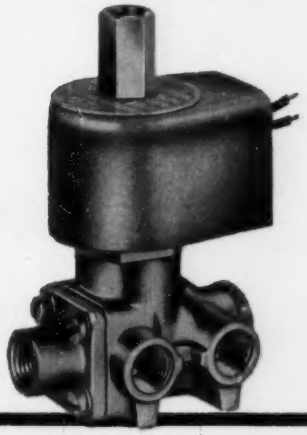
TESTING helps insure positive BRASS CO. forgings, assemblies . . .

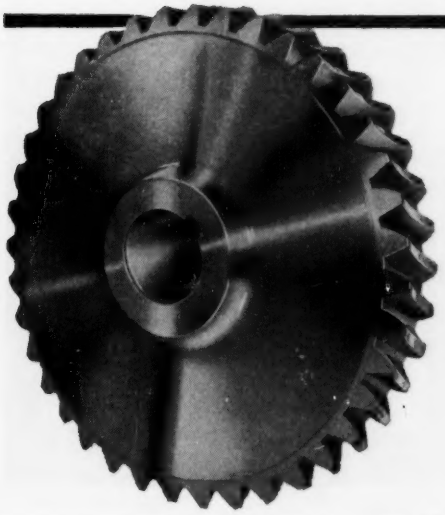




The direct reading spectrometer (Left) makes it possible to accurately analyze an alloy for chemical composition within 90 seconds while the metal is in the molten stage. A sample specimen is poured, cooled and sent to the laboratory, where it is placed in the spectrometer. Through the diffraction gratings in the machine, the "spectrum" analysis of the alloy records its exact chemical composition. With this equipment, alloy specifications are matched exactly, thus insuring a better finished product through Positive Quality Control.

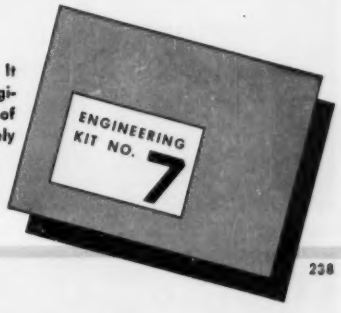
THIS MIDGET 4-WAY SOLENOID VALVE (Right) is one of a complete line designed and manufactured by the Automatic Switch Co. (ASCO) of Florham Park, New Jersey. Valves of this type are used for controlling small double acting cylinders which operate valves, dampers and many types of automatically controlled equipment. One of the most important components in these valves is the non-porous brass body forged by the Mueller Brass Co. who also perform all the major machining operations so that the body is ready for use upon delivery. The forged brass body insures freedom from porosity and reduces possibility of corrosion. The Mueller Brass Co. Positive Quality Control program insures ASCO complete "product protection". . . and eliminates chance of "in-service" failures.





THIS LARGE 18" FORGED GEAR, along with two others of the same type, is used in a steam turbine installed in a power generation facility of the Wisconsin Electric Power Company, at Port Washington, Wisconsin. The gear was forged in open dies by the Mueller Brass Co. from tough, long-wearing 603 alloy. The gear operates at 25-30 RPM and is turned by the turbine, which has a capacity of 80,000 kilowatts. Strength and dependability are of utmost importance in applications like this, and in such cases Positive Quality Control insures peak performance.

Write for your engineering kit no. 7. It contains complete laboratory and engineering data plus typical examples of Mueller Brass Co. products used in widely diversified applications.



238

MUELLER BRASS CO. PORT HURON 20, MICHIGAN

1649 TIMERS

that **SOLVED** special control problems.

• How this engineering experience can help you.

The small Time Delay Timer represents one of the simplest motor driven timers we manufacture. It is a reliable standard fixed time delay type.

Industrial Timer also manufactures this Punched Tape Programmer which controls 85 individual load circuits through an unlimited number of steps. No coding or elaborate memory systems are required, making possible direct control from Programmer to process.

Between these two extremes we list 1688 different timers, of which 39 are standard types and 1649 are "specials" developed to solve difficult control problems.

Most timing problems have their own unique characteristics. However, it very often happens that a control problem is quickly solved by one of these 1649 already developed special timers. If not, we have the staff, the experience (20 years) and what's more important, the desire to design and deliver the timer that fills your needs 100%. Send us your specifications.

COMPLETE NEW TECHNICAL BULLETINS NOW READY
Ask for complete catalog or individual bulletins by number

Complete Catalog Timing Controls

No. 100 Card & Tape Programmers

No. 200 Motor Driven Cam Timers

No. 201 Multi-Cam Timer Kit

No. 300 Motor Driven Time Delay Timers

No. 400 Motor Driven Interval Timers

No. 500 Motor Driven Recycling Timers

No. 700 Time Meters & Time Totalizers

No. 800 Explosion Proof Timing Controls

AFFILIATE — LINE ELECTRIC COMPANY

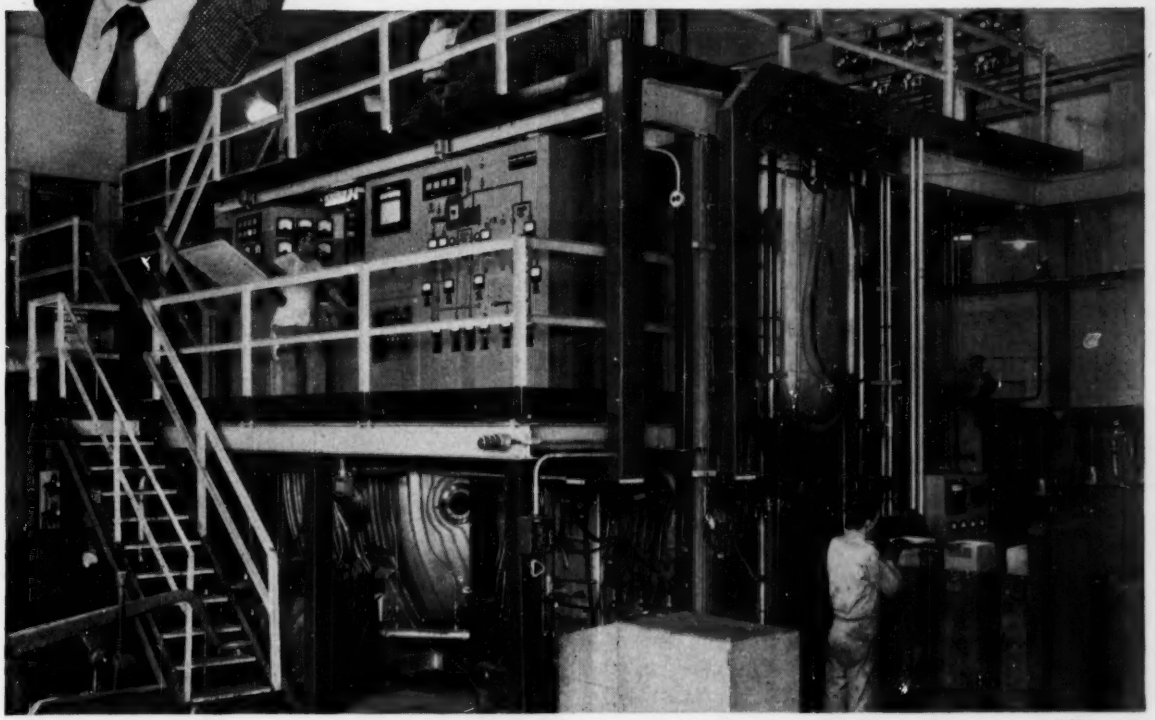
Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

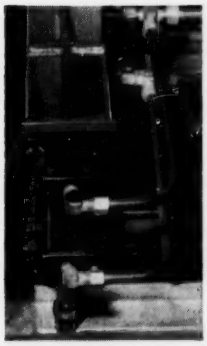
1413 McCARTER HIGHWAY, NEWARK 4, N. J.

"Our experience demonstrated that hydraulic line rupture can occur in proximity to molten metal without fire when Cellulubes are used . . ."

Mr. Arthur E. Franks of Vacuum Metals Corporation, Syracuse, N.Y.



". . . this is why fire-resistant Celanese Cellulube hydraulic fluid is in use in the world's largest vacuum furnace at Vacuum Metals Corporation."



Hydraulic Controls on the world's largest vacuum furnace

In designing the hydraulic controls for its 2500-pound vacuum melting furnace, Vacuum Metals selected Cellulube hydraulic fluid because of its fire resistance and low vapor pressure characteristics. Laboratory tests and operating experience demonstrated that the unique combination of Cellulubes' properties made it the ideal material for this application.

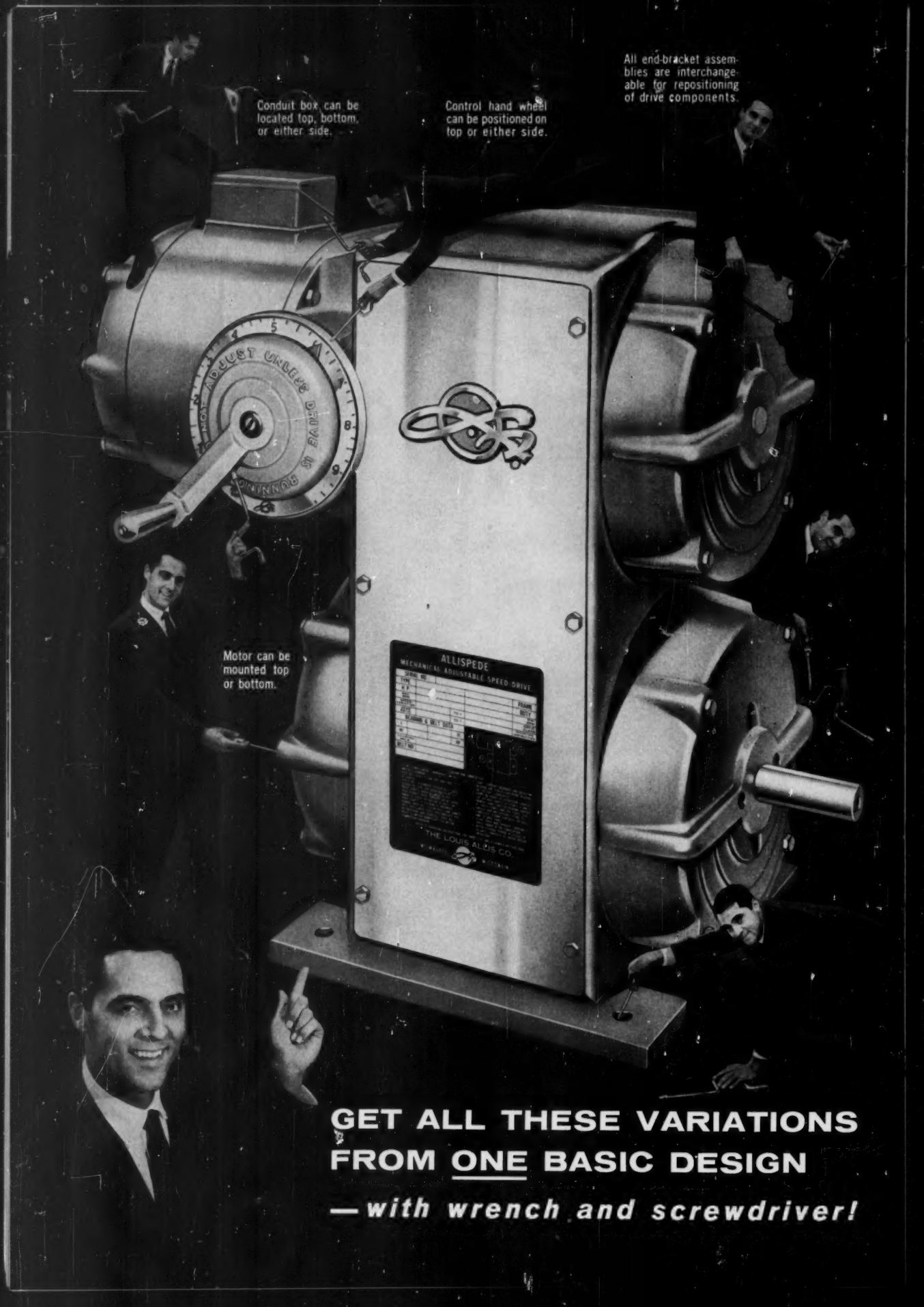
These findings are typical of Cellulubes' performance during continuous operation under critical conditions. As hydraulic fluids, Cellulubes reduce the dangers of fires and explosions caused by line breaks or other equipment failures. As air cylinder lubricants, Cellulubes prevent the formation of excessive carbon deposits—the main source of compressor fires and explosions.

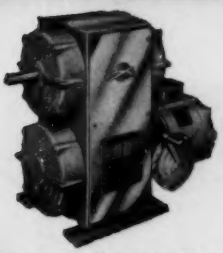
Available in 6 controlled viscosities, Cellulubes can be supplied to meet exacting requirements in the replacement of flammable fluids presently in use. Play it safe, write for complete data and technical assistance. Celanese Corporation of America, Chemical Division, Dept. 565-A, 180 Madison Ave., N. Y. 16.

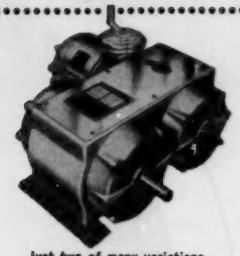
Celanese®
Cellulube®

Celanese
CHEMICALS

Circle 451 on Page 19


Conduit box can be located top, bottom, or either side.
Control hand wheel can be positioned on top or either side.
All end-bracket assemblies are interchangeable for repositioning of drive components.
Motor can be mounted top or bottom.
DO NOT ADJUST UNLESS DRIVE IS RUNNING
ALLISPEDE
MECHANICAL ADJUSTABLE SPEED DRIVE
THE LOUIS ALLIS CO.
GET ALL THESE VARIATIONS
FROM ONE BASIC DESIGN
— with wrench and screwdriver!





Just two of many variations that can be made from a standard ALLISPEDE DRIVE.

Another NEW product from Louis Allis

The ALLISPEDE* DRIVE gives you complete design versatility!

"Building-block" principle, using one basic unit, permits this drive to fit into any design requirement regardless of space or shape limitations!

The *all-new* ALLISPEDE DRIVE is a simple answer to the problem of providing low-cost adjustable speed in a variety of designs. The basic unit goes together like blocks — you pick the assembly you want — locating feet, end brackets, control hand wheel, conduit box, and output shaft to suit the requirements of the driven machine.

Output shaft can be high or low, right or left.

The same unit can be used for horizontal or upright floor, wall, or ceiling mounting — there are no "fixed" components to limit installation. And all of these adjustments are easily made in minutes with just a wrench and screwdriver, right on your assembly floor! As a result, a lower inventory of drives still covers your production requirements.

Superior design improves drive efficiency and extends service life. The four bearings equally distribute belt load, increasing bearing and belt life. Movable discs slide smoothly on internally-lubricated splined shafts — won't stick in place or wear.

Rugged cast-iron housing with plated steel covers shields drive against dirt and corrosion . . . integral rotor fan cools the motor and force-ventilates the drive housing to extend bearing life. Oversize cartridge bearings are pressed on shaft and lubricated at the factory. Corrosion-resistant stainless-steel nameplates diagram proper motor connection, specify bearing sizes, and carry complete instructions for operation and lubrication.

Detachable feet can be bolted to bottom, side, or top for floor, wall, or ceiling mounting.

The ALLISPEDE DRIVE can be supplied with in-line or right-angle integral gears, brake, and tachometer. Sizes from 1 to 20 HP, with speed variations up to 8:1. Electrical and mechanical modifications for any application.

Contact your Louis Allis District Office or Distributor for complete information and engineering assistance. Or write for Bulletin 3300, The Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wis.

**ALLISPEDE is a trademark of The Louis Allis Co.*

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 452 on Page 19

Tubexperience in action

"They use this Super Alloy tubing in missiles, rockets and jets

—so you know it can lick your heat and corrosion problems!"

*"It's made by Superior Tube in your choice of 16 different materials. Believe me, this tubing can take the severest conditions of heat, corrosion and oxidation. Has very high fatigue and creep strength even at temperatures over 1000°F."

If you have a temperature and corrosion problem that causes failure no matter what type of tubing you have tried, get your Superior distributor to order Super Alloy tubing for you—it is the tubing for virtually every critical application of this nature.

Super Alloy tubing offers the important properties mentioned above, plus the dependability and longer service life built into it by Superior skills and experience. We will put your tubing through many special examinations if you want us to—eddy current and ultrasonic, hydrostatic, and hot tensile tests, stress rupture tests, qualitative and quantitative analysis, and many others—for your complete assurance in its ability to perform as required.

Our continuing test program on Super Alloy tubing has amassed much useful information on mechanical properties. You will want to make a study of them and their potential for use in your applications. They are covered in our Bulletin 70. Send for copies. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

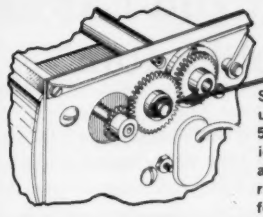
NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

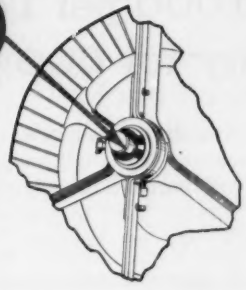
Truarc Rings Eliminate Parts and Machining, Speed Assembly, Reduce Manufacturing Costs

Ring eliminates nut and threading, saves $365/M



Sanborn Co., Waltham, Mass., uses a Waldes Truarc Series 5555 Grip ring* to secure the idler gear assembly of its portable electrocardiograph. The ring assures faultless gear performance necessary for diagnostic accuracy, eliminates a nut and threading operation for savings of $365 per 1000 units.

Ring saves parts, speeds assembly for savings of $260/M

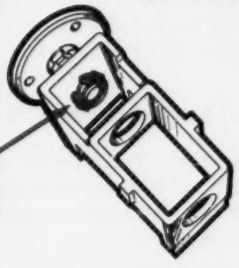


Fraser and Johnston Co., San Francisco, Calif., uses a Series 5555 Grip ring* to secure the fan shaft and speed assembly of its furnace blowers. The ring eliminates a collar and set screw for savings of $180/M on materials, $80/M on assembly time—a total of $260 per 1000 units.

2 standard rings replace 4 special parts, save $170/M

Sanymetal Products Co., Inc., Cleveland, O., uses a Series 5005 Self-locking ring and a Series 5103 Crescent® ring* to hold the escutcheon plate and handle of this doorlatch for toilet compartments. The two standard rings replace four expensive chrome-plated brass parts for savings of $170 per 1000 units.

Ring replaces spring and washer; speeds assembly 50%, saves $15/M



Allen-Bradley Co., Milwaukee, Wisc., uses a Series 5139 Prong-Lock ring* to secure the adjustment knob of its pneumatic timer. Ring eliminates a costly coil spring and washer, simplifies a tough assembly operation. Cost saving: $15 per 1000 units. Assembly time saving: 50%.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get:

Statistically Controlled Quality from raw materials to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U. S. and Canada.

Field Engineering Service: More than 30 engineering minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today .. let our Truarc engineers help you solve design, assembly and production problems . . . without obligation. e.2

WALDES

TRUARC®

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, N.Y.

Consult the Yellow Pages of your Telephone Directory for name of Local Truarc Factory Representative and Authorized Distributor. Look under "Retaining Rings" or "Rings, Retaining."

Waldes Kohinoor, Inc., Long Island City 1, N. Y.

Please send me your new 24-page Catalog No. RR 10-58 with descriptions and illustrations of the complete line of Truarc retaining rings, pliers and accessory tools and 80 typical applications.

(please print)

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

MD-19

©1958 Waldes Kohinoor, Inc.

*Covered by one or more of the following patents: Nos. 2,382,948; 2,491,306; 2,574,034; 2,755,698.

Circle 454 on Page 19

Memo on Metals

New Age-hardenable Titanium Alloys Offer Up to 220,000 psi Tensile Strength and Easier Formability for 600 to 1,000 F Applications

Three new age-hardenable titanium alloys may prove to be the solution to many of the strength-weight and temperature problems encountered in designing advanced aircraft and missiles. They may also prove extremely economical for such applications.

All three offer much higher strengths than other titanium alloys – and have the light weight and corrosion resistance typical of titanium alloys. Furthermore, they are readily FORMAGEABLE* – capable of being formed in the solution-treated or "soft" condition and then strengthened by simple thermal aging techniques. Each is now in pilot production and available in limited quantities of mill products.

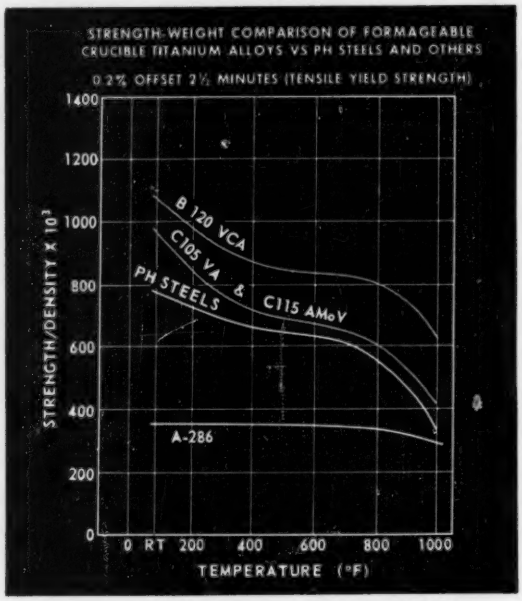
First Age-hardenable All-beta Ti Alloy

Crucible B-120VCA is the first useful titanium alloy with an all-beta (high temperature) structure. It has both the highest strength and best formability of any titanium-base alloy.

This alloy's composition (13%V-11%Cr-3%Al) enables its structure to stay all-beta during forming and/or during slow cooling, and to age to high strength levels at temperatures where distortion is not a problem.

B-120VCA has a unique combination of properties. Room temperature strengths of 200,000 to 250,000 psi have been obtained. On a strength-weight basis this is the highest strength of any available structural material. In short-time elevated temperature tensile tests (1-2 minutes), it offers a decided strength-weight advantage over alternate materials at temperatures up to at least 1,000 F. Under creep conditions, for very long periods of time, it enjoys a strength-weight advantage up to at least 600 F. Beyond this limit, the other Crucible FORMAGEABLE titanium alloys are recommended.

B-120VCA is ductile-weldable, cold-headable, and has great and deep hardenability. Because of this formability, it should prove suitable for applications such as aircraft skins, stiffeners and other primary structural shapes, and for missile pressure tanks, rocket motor cases and structural members. Preliminary tests indicate it may prove unequalled as a construction material for honeycomb assemblies. Because



it is so easy to cold-head, it has a large potential in such items as rivets.

Alpha-beta Titanium-base Alloys

Crucible C-105VA is an alph-beta titanium-base material which also is FORMAGEABLE. Its 16% vanadium content stabilizes a sufficient amount of the beta phase for good age-hardenable response; the 2.5% Al content improves the alloy's elevated temperature properties.

C-105VA resolves two conflicting requirements for aircraft sheet material. It is soft, ductile and easily formed in the solution-quenched condition. Because the formed parts can be aged subsequently at moderate temperatures, parts made of C-105VA can possess high strengths at temperatures up to 800 F for long periods of time.

* *age-hardenable titanium alloys*
* *tool steels in production parts*
* *borated stainless steels*

This third alloy, C-115 AMoV (4%Al-3%Mo-1%V), also shows considerable promise for aircraft sheet applications. It is age-hardenable to higher strengths than C-105VA with only slight sacrifice in forming characteristics.

Considerable data on the properties and fabricating qualities of all three alloys have been assembled by Crucible's Titanium Division. For data sheets and additional information, send the coupon.

Tool Steels Replace Standard Alloys for Production Parts

As design and metallurgical engineers require materials with improved properties or greater uniformity, they are turning more to the use of tool steel for production parts. Here are three good examples:

1. Vanes in the hydraulic system that actuates the automatic steering mechanism on cars are made of Crucible REX® M-2 high speed steel. REX M-2 combines the abrasion resistance necessary for minimum wear with the impact resistance needed for long life and safety. The manufacturer experimented with numerous other steels, but high speed steel lasted longer than any other type tested.

2. Actuator bars for a nationally-known calculator are now being produced of Crucible KETOS® – a low-priced AISI Type O1 alloy tool steel – because the thin, close-tolerance contact edges withstood over 4-million high speed blows in a life test. No other steel has lasted more than 1-million cycles before chipping and failing.

3. Cylinder block for a fast acting, aircraft hydraulic pump made of Crucible Chrome tool steel. Pump operates at temperatures up to 500 F, pressures to 5,000 psi. Tool steel was selected over a standard AISI alloy because of its high degree of cleanline ss, uniform response to heat treatment, and controlled hardenability. Furthermore, because tool steel practices are employed in making it, the steel more consistently meets the critical mechanical and physical properties required in this application.

For data sheets on these and all other Crucible tool steels – send the coupon.

High Boron Stainless Steels Made Possible by Vacuum Melting

Type 304 stainless steel with boron has proved to be an excellent material for nuclear equipment, because the boron readily absorbs neutrons. By increasing the boron content, valuable weight and thickness reductions can be made in reactor shielding and control rods.

Unfortunately, conventionally melted borated 304 becomes "hot short" – virtually impossible to work if the boron content exceeds 1%. Vacuum melting has provided the answer to this problem. Vacuum-melted 304 stainless is readily workable when the boron content goes up to 2% or even higher.

Vacuum melting the alloy also provides closer control of the composition, because only pure materials are used. So, undesirable elements such as cobalt – which becomes radioactive upon bombardment – can be kept to a minimum. In fact, vacuum-melted Type 304 stainless can be supplied with less than .001% cobalt.

For additional information on vacuum-melted steels – send the coupon.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EA07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:

1. Data sheets on B-120VCA ☐ C-105VA ☐ C-115AMoV ☐
2. A copy of "Titanium Alloys for Aircraft and Spacecraft" by Finlay, Vordahl and Malone ☐
3. Data Book on Crucible tool steels ☐
4. Data sheets on vacuum-melted steels ☐

Name_____ Title_____
Company_____
Street_____
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

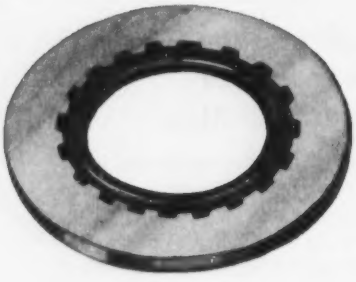
*Reg. Trade Mark

Circle 456 on Page 19

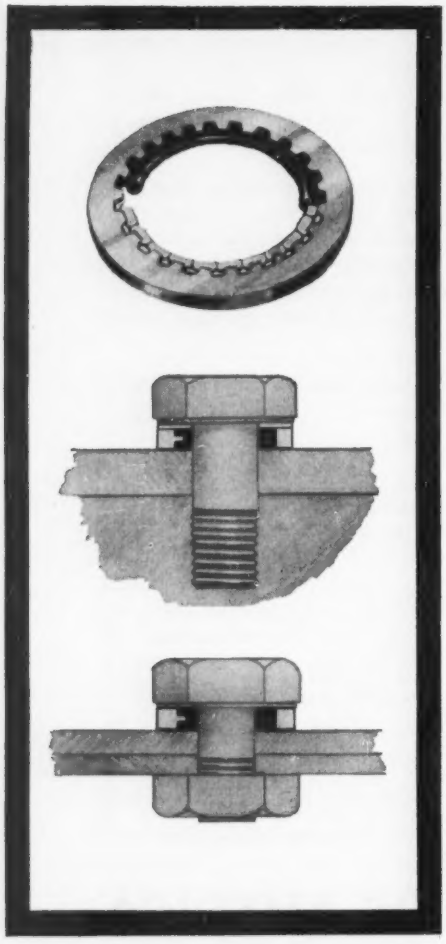
FOR SEALING.

NOW IT COSTS NO MORE

FOR THE SUPERIORITY OF



Stat-O-Seal®



Only Stat-O-Seals offer safe, sure, effective sealing using the principle of controlled confinement of the seal plus the advantages of *mechanical* "bonding".

This means they will not "twist" in installing and there is no chemical bonding agent that can be attacked by corrosive fluids. Stat-O-Seals feature:

- Metal to metal contact of faying surfaces
- Quick, visual inspection
- Easy, one piece, "twist-free" assembly
- Re-useability
- O-ring style configuration for versatility and freedom from easy damage
- Sure sealing from high vacuum to 20,000 PSI
- Standard sizes for bolts and nuts from −6 to 2" and types to seal almost any fluid at temperature ranges from −85° to +360°F.

Stat-O-Seals have been proven in thousands of vital installations and now they cost no more than ordinary seals for similar purposes.

If your product and designs require seals, why not find out how Stat-O-Seals can do a better job for you, too.

by the makers of Gask-O-Seal *and Met-O-Seal*

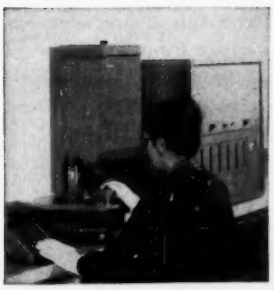
Parker
SEAL COMPANY*
CULVER CITY, CALIF. • CLEVELAND, 12, OHIO
A DIVISION OF Parker Hannifin CORPORATION

**Formerly Franklin C. Wolfe Co. and Parker Rubber Division*

Circle 457 on Page 19

Barden Precision 102H5 bearing as used in a high speed grinding spindle at the Barden plant

BARDEN *bearings help Barden make better bearings*



Fringecount Micrometer, an ultra-precision interferometer, is used by Barden for the absolute measurement of dimensional masters to one millionth of an inch. This basic reference gage provides the ultimate in quality control instrumentation, assuring consistent accuracy of Barden Precision ball bearings.

Precision spindle performance demands low vibration, high rigidity and maximum rotational accuracy at extreme speeds, all maintained over extended periods of service.

Because *Barden Precision* spindle bearings meet all these requirements — and more — they are used in the most precise machine tools being built today. To the user of precision spindles, they bring high performance and dependability that is measured by the superior quality of machine output.

In the Barden plant the closest-tolerance grinding operations are performed on high speed grinders fitted with *Barden Precision* spindle bearings. Barden production men discovered long ago that it takes bearings of the highest precision and performance to grind bearing parts to their rigid specifications.

In this unique cycle of manufacturing, *Barden Precision* spindle bearings help make better Barden bearings of all types and sizes . . . better because Barden production experts are their own most critical customers.

The result: spindle bearings that measure up to the highest standards of production quality.

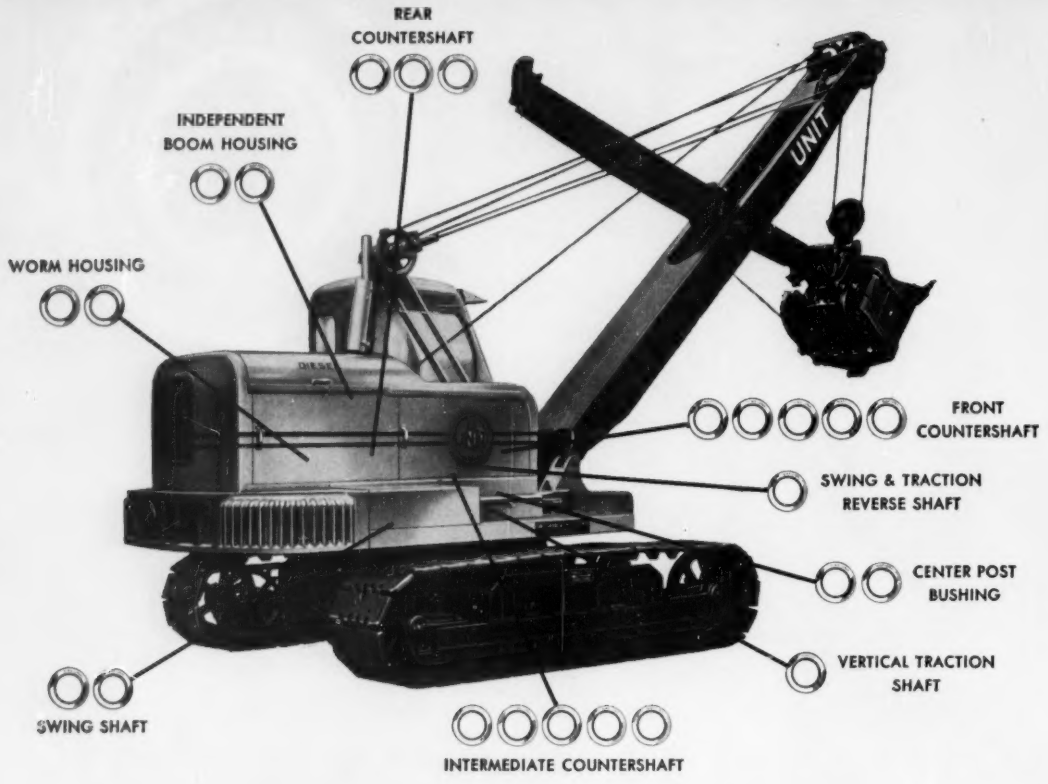
THE BARDEN CORPORATION

73 E. Franklin St., Danbury, Connecticut • Western office: 3850 Wilshire Boulevard, Los Angeles 5, Calif.

SPECIFY BARDEN PRECISION BALL BEARINGS FOR: MACHINE TOOL AND TEXTILE SPINDLES • INSTRUMENTS • AIRCRAFT ACCESSORIES • COMPUTERS AND RECORDERS • OTHER PRECISION APPLICATIONS

Circle 458 on Page 19

NATIONAL OIL SEAL LOGBOOK



National Oil Seals used at key points throughout UNIT Crane & Shovel excavators

UNIT Model 1020 pictured above is a ¾ yard diesel excavator designed for maximum convenience and versatility in medium-duty applications. As in other UNIT excavators, National Oil Seals are installed at key points to retain lubricant, exclude dirt and water, and prolong life of bearings and assemblies.

In the UNIT 1020 Excavator, a total of 23 National Seals are employed in 9 basic subassemblies. These include front, rear and intermediate countershaft assemblies, swing traction reverse shaft, the turntable center pin assembly, vertical swing shaft, worm housing and traction shaft assemblies.

Grease seals used in the Model 1020 are of the National 50,000 series design, employing a spring-tensioned leather sealing member mounted inside a precision-made steel outer case. Shaft sizes range from 11/16" in the intermediate countershaft assembly to 8" on the turntable center pin. Similar use of National Seals is made in 11 other excavators offered by UNIT.

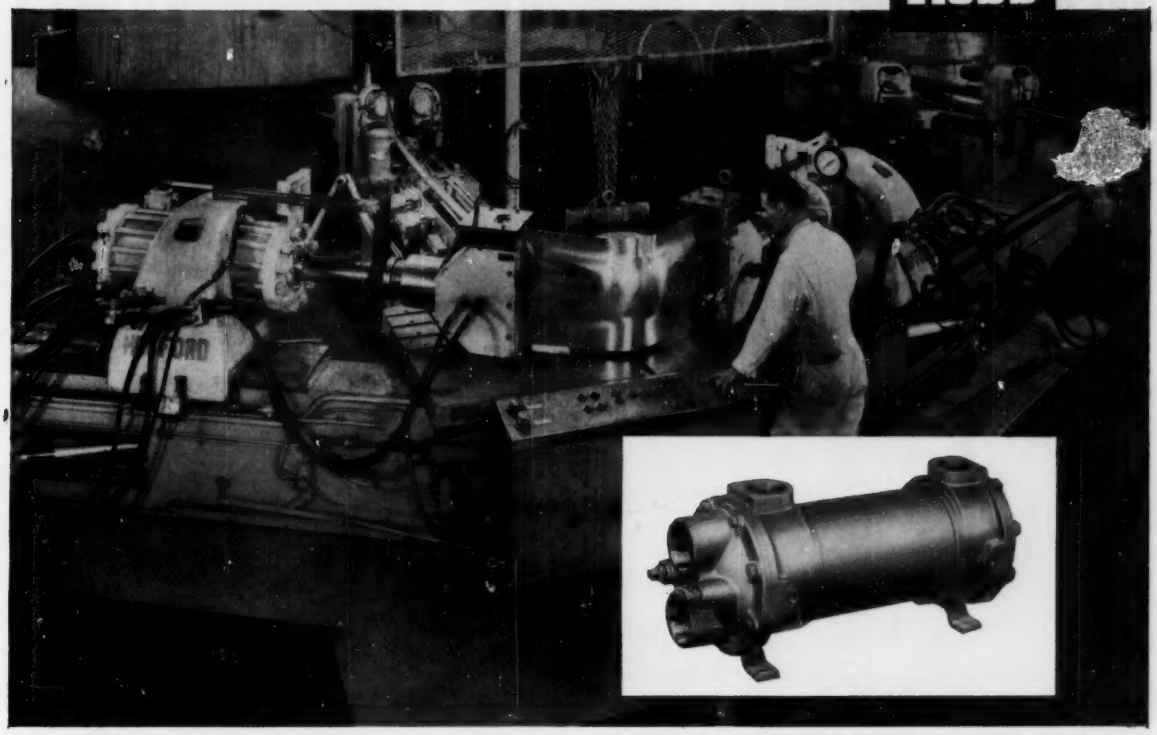
National Seals used in the UNIT Model 1020 are all of standard design; National offers over 2,500 different such seals or can design special seals for special requirements. Call your National Applications Engineer. He's listed in the Yellow Pages, under Oil Seals.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Downey and Redwood City, California

Circle 459 on Page 19

HYDRAULIC FLUID COOLING BY ROSS



Radar reflectors pulled into shape with 118,000 pound stretch

Shaping aluminum radar reflectors, this Hufford Hydraulic Stretch-Wrap Forming Machine exerts up to 118,000 pounds of pull with its powerful jaws. With the metal drawn to its yield point and wrapped around a stationary die, curvature is compounded in two directions without wrinkles.

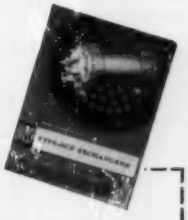
To maintain consistent hydraulic pressures by preventing pump slippage from overheated, thinned oil, a Ross Type BCF Exchanger was installed as original equipment. Even under highest pressure, hydraulic temperature remains within desired limits. *Efficient cooling is assured.*

Says Hufford Machine Works, Inc., "Ross Exchangers are compact, easy to install and perform satisfactorily . . . We have been using them for years."

First in ruggedness and high thermal efficiency, Ross Exchangers are regularly furnished with practically every type and make of hydraulic machinery: die casters, metal drawing presses, extrusion presses, gear shapers, powdered metal presses and fluid drives.

Recently redesigned, Ross Type BCF Exchangers feature *new* flanged-lip baffles for tighter tube fit and improved thermal characteristics, *new* movable feet for easy installation, *new* materials, *new* sizes and capacities in one, two or four pass designs.

For detailed information on these pre-engineered, fully standardized units, use coupon below to request new Bulletin 1.1K6.



TO:
American-Standard
Ross Heat Exchanger Division
Buffalo 5, N. Y. MD 159

Please send, without obligation, your new Bulletin 1.1K6 describing the redesigned Ross Type BCF Heat Exchanger.

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

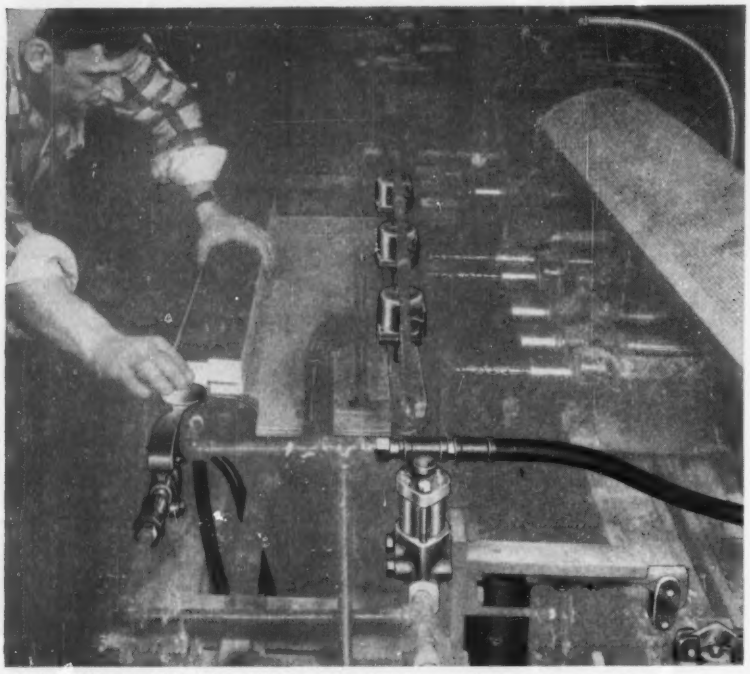
*American-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

American-Standard Products

AMERICAN-Standard

ROSS HEAT EXCHANGER DIVISION

ECONOMIZE ON YOUR GANG-TOOLING WITH STANDARD SCHRADER AIR PRODUCTS

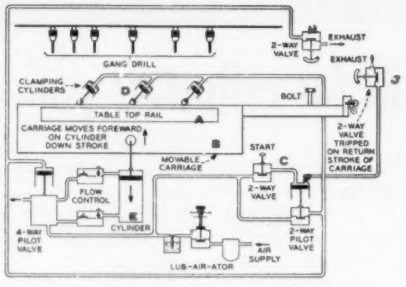


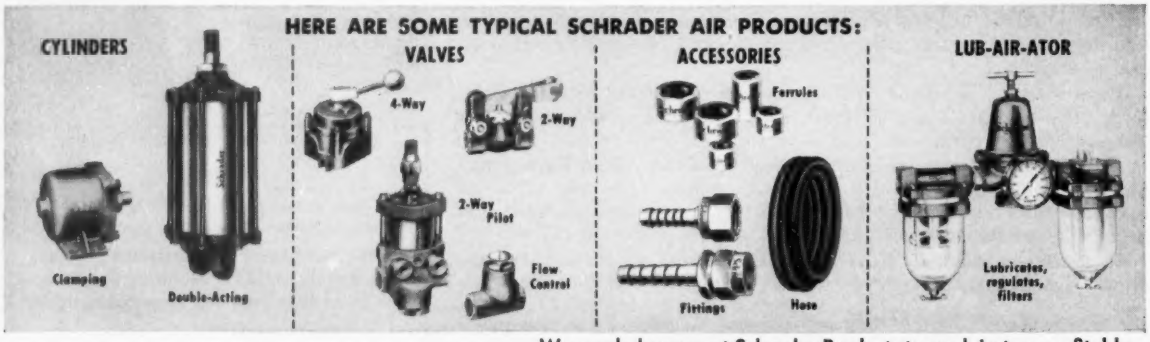
Many plants use air to plan their own gang-tool units. They design them with standard Schrader parts and save money. They know it pays to think "air" whenever they automate such jobs as holding, moving, tripping, feeding, ejecting.

Air pays off because it is also safe, fast, and accurate . . . as well as versatile and economical. Use it for the trickiest jobs in the shop. Schrader air specialists will help you select the *right* components from the most complete line of air products.

ANOTHER TYPICAL SHOP PROBLEM SOLVED BY STANDARD SCHRADER PRODUCTS: Six holes had to be drilled in table tops. How to increase production and speed up the drilling, without increasing costs? Operator places tabletop rail A on movable carriage B and presses valve C. Clamping cylinders D hold rail in position. Cylinder E advances carriage to drills. Holes are drilled in rail to exact depth. Carriage returns to position when valve H is tripped and reverses 4-way valve. Valve J exhausts pilot valve F and clamping cylinders release rail.

RESULT: Production increased 80% with an economical Schrader-controlled fixture.





We can help you put Schrader Products to work just as profitably and our Distributors are conveniently located for fast delivery. Information is available by writing directly to us—

A. SCHRADER'S SON, *division of Scovill Mfg. Co., Inc.*
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

Schrader®
a division of SCOVILL

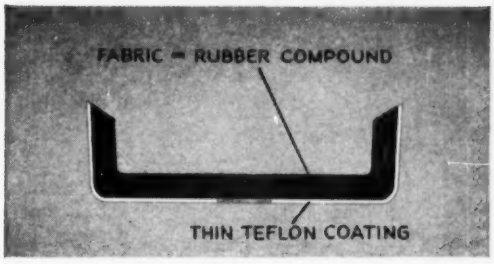
QUALITY AIR CONTROL PRODUCTS

Circle 461 on Page 19

NEWEST OF THE GARLOCK 2,000

First Advance in Cup Design in 30 Years

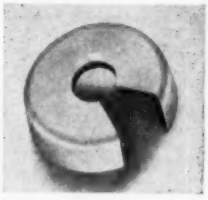
New Garlock TEFLON-Coated Cups



Cutaway shows how TEFLON coating is applied to outer surface of molded cup by special Garlock process. Coating becomes integral part of outer surface.

This exclusive Garlock development will substantially improve the operation of your hydraulic or pneumatic equipment.

TEFLON-coated cups reduce the breakaway torque required to operate cylinders; reduce running friction; will not stick to cylinder walls even after long periods of idleness. Completely eliminate "squealing." All this, of course, results in longer life, less downtime.



TEFLON, with its low coefficient of friction and anti-sticking characteristics, has for many years resisted the efforts of manufacturers to use it as a coating. The very anti-sticking qualities that make it desirable, also made it difficult to work with. Now Garlock has perfected a technique for coating molded cups with a thin layer of TEFLON. This coating becomes an integral part of the cup.

Most important, of course, TEFLON-coated cups are low in cost, only slightly higher than ordinary cups.

Get full information on this newest member of "the Garlock 2,000" . . . two thousand styles of packings, gaskets, and seals for every need. Call your local Garlock representative or write for Folder 145. You'll find information on other Garlock products in Sweet's Product Design File.

Other New Garlock TEFLON-Coated Products

To reduce friction and reduce downtime at low cost on applications using V-type packings or O-rings Garlock also furnishes TEFLON-coated CHEVRON* packing and TEFLON-coated O-rings. Both have the same exceptional anti-friction qualities of TEFLON-coated cups. These products are available in all the standard sizes. Write for CHEVRON folder AD-115; or O-Ring Folder AD-148.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Circle 462 on Page 19

Color micrograph of heat tinted section of ferritic Malleable iron showing random dispersion of temper carbon nodules in ferrite. 625X magnification.

Usability is Malleable

In the growing world of metals, certain requirements remain basic: strength . . . versatility . . . economy. Malleable iron castings uniquely answer all three. Malleable castings provide more strength per dollar than any other metal . . . are the most machinable of all ferrous metals of similar hardness.

From the great range of Malleable irons now produced in modern Malleable foundries, you can select exactly the right metal to fill your most demanding needs for endurance, resistance to impact and wear, ductility and constant uniformity. No other metal offers you so much at so low a cost.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Select the Best Metal to Perform a Given Set of Functions

Any equipment part can be described, at least approximately, in terms of the functions it must perform. That is, it must provide a certain strength plus resistance to wear, fatigue, impact or corrosion. The finished part must provide the best combination of all necessary factors at the lowest possible cost — a cost that must include machining, finishing and assembly where applicable.

Unique Production Method Combines Desirable Characteristics

The amount and form of carbon in ferrous metals is of prime importance. The carbon content of Malleable iron (2.00 to 2.60%) provides good fluidity at the pouring stage. Yet neither flake graphite nor combined carbon is present in finished standard Malleable iron.

As the photomicrograph of standard Malleable iron shows, the carbon has been transformed into temper carbon nodules in a matrix of ferrite during the heat-treatment given *all* Malleable iron castings. The result is a metal with a unique combination of high strength, toughness and machinability.

Pearlitic Malleable irons differ from standard, or ferritic, Malleable only in that a controlled amount of the carbon is combined with the iron to form a pearlitic matrix around the temper carbon nodules. This increases strength, hardness, wear resistance and modulus of elasticity, while retaining good ductility and machinability.

TENSILE PROPERTIES — A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons				
Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Elongation % in 2 in.	Ratio of Tensile to Yield %
Standard				
35018	53,000	35,000	18	66
32510	50,000	32,500	10	65
Pearlitic				
45010	65,000	45,000	10	69
45007	68,000	45,000	7	66
48004	70,000	48,000	4	69
50007	75,000	50,000	7	67
53004	80,000	53,000	4	66
60003	80,000	60,000	3	75
80002	100,000	80,000	2	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

TYPICAL BRINNELL HARDNESS NO. RANGES

Pearlitic Malleable Irons							
Designation	45010	45007	48004	50007	53004	60003	80002
B. H. N.	163-207	163-217	163-228	179-228	197-241	197-255	241-269

New Savings Result

From the wide range of properties obtainable, a Malleable iron may be selected that will most completely meet ideal design and functional requirements. Because of the great latitude of producible sizes, from a fraction of an ounce to hundreds of pounds, Malleable can be used for a wealth of applications.

Malleable iron's economy is derived in two ways. First, the casting process is generally accepted as the most economical method of producing a finished part. Secondly, being the most machinable of all ferrous metals of similar hardness, cast or otherwise, Malleable iron castings provide exceptional economies in time, tool and power consumption.

Today's Malleable iron castings offer tremendous strength, uniformity, versatility and economy. The producers of Malleable castings are anxious to assist you in getting maximum "usability." Why not let their modern design, testing and production facilities work for you?

Send for Special Data Unit

Your copy of Data Unit No. 101 containing additional information on the benefits you can derive from Malleable iron castings is available from any member of the Malleable Castings Council. If you wish, you may direct your request to **Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.**

Circle 464 on Page 19

BEARING TIPS
by McGill

McGILL sealed GUIDEROL® bearings preserve high capacity performance of needle bearing applications

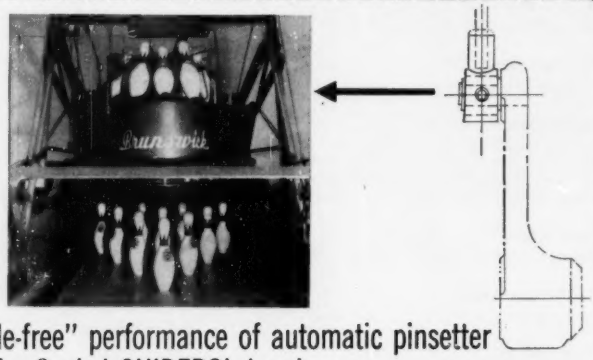
Lip type contact seals built into GUIDEROL bearings insure longer life for their high capacity performance in limited radial space. It's simpler and less costly to apply these sealed bearings than build in auxiliary seals that increase bearing width and housing requirements.

GUIDEROL bearings, including the sealed series, are precision built and combine the inherent high capacity of full complement roller bearings with the control of center guided rollers. This recommends the bearing for applications too heavily loaded for retainer type bearings, but where shaft deflection and misalignment prevents the use of ordinary full type roller bearings.

Seals keep contamination out and lubrication in. This assures trouble free performance where maintenance is costly or impractical.

Sealed GUIDEROL minimizes torque in ACF "Piggy-Back" trailer hitch

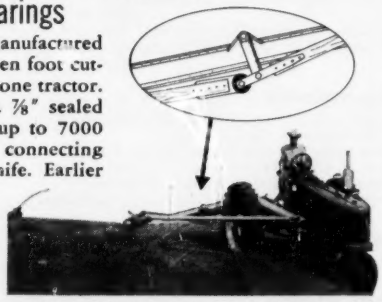
McGILL Sealed GUIDEROL bearings meet the requirements of a high capacity needle bearing for small radial space, having adequate seals to prevent entry of foreign materials and loss of lubricant in this exposed application. The bearings, in the elevating arms, minimize the amount of torque required to elevate the trailer hitch and jack the trailer off the car floor. The hitch, manufactured by American Car and Foundry Division of ACF Industries Incorporated, is a tiedown and cushioning unit for semi-truck trailers on flat car (Piggy-back) use. Although speeds are low, loads are as high as 20,000 lbs. per bearing. Grease relubrication when desired is applied through the shaft to the inner race of the bearing.



"Trouble-free" performance of automatic pinsetter called for Sealed GUIDEROL bearings

Prelubricated and Sealed GUIDEROL bearings are used in two applications in BRUNSWICK AUTOMATIC PINSETTERS; on the Rake Crank Lever Assembly and on the Jogger Arm Assembly. The photo shows the location of the sealed GUIDEROL Rake Crank Lever application in the "mechanical brain" of the machine. The sealed GUIDEROL bearings help keep the "brain" highly efficient, with a minimum of maintenance. In the Rake Crank they are not relubricated and operate indefinitely on retained lubricant. Effective seals keep out dirt and foreign matter.

New mower design takes high cutting loads on Sealed GUIDEROL bearings



These unusual field mowers manufactured by Kosch Mfg. Co. use two seven foot cutting bars for a 14 foot cut with one tractor. The second bar depends on a ⅞" sealed GUIDEROL bearing to carry up to 7000 pound loads produced in the connecting drive for the reciprocating knife. Earlier sleeve and lower quality needle bearings were discarded for sealed GUIDEROL bearings that have prevented costly field breakdowns.

engineered electrical products

McGILL®

precision needle roller bearings

SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

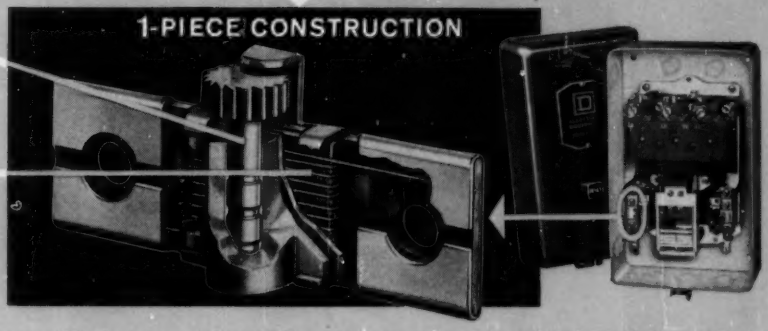
McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 465 on Page 19

When you buy Motor Starters--

YOU PAY FOR OVERLOAD PROTECTION

...BE SURE YOU GET IT!



Heat-responsive element (solder pot) provides accurate response to overload, yet prevents nuisance tripping.

Heat-producing element is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.

Only ONE-PIECE Overload Relays can give 100% Protection Only with ONE-PIECE construction can you *know* you've installed the heater correctly. Only with ONE-PIECE construction can you *know* the heater is exactly centered, or properly positioned, so that it performs according to its rating. Only with ONE-PIECE construction can you *know* your starters will not operate without the thermal units properly installed. Only with ONE-PIECE construction can you *know* your motors have full protection.

Only Square D has ONE-PIECE Construction ONE-PIECE construction *eliminates* any possibility of heater misalignment. Square D melting alloy thermal overload relays can be installed only one way. They are tamper-proof. They are factory-assembled, are *individually* calibrated and tested. Repeated tripping will not affect their accuracy.

Insist on Square D starters with melting alloy thermal overload relays

Let your Square D Field Engineer show you 1 how one-piece construction is accomplished and how easy it is to mismatch separate heaters and solder pots— 2 an endurance tester to prove that overload units can be reset repeatedly without damage while the solder is liquid — 3 a tripping time tester to compare various types of melting alloy units and to prove that tripping time won't change after repeated operation.

Individual factory inspection of every Square D melting alloy thermal overload relay means performance you can trust. Each unit is calibrated and thoroughly tested to make sure it will perform according to its rating.

Write for Bulletin SM-275 for the complete story on Square D starters with ONE-PIECE thermal overload relays. Address Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin

SQUARE D COMPANY

Will Help Control Enormous Volumes of Steam

This odd-shaped forging is as husky and rugged as it looks. It's an interceptor valve body, made of electric-furnace alloy steel, and it's going to be pitted against the forces of steam. The finished valve will be one of the flow-control units in a big turbine system.

Starting with a corrugated ingot, Bethlehem forged and machined the part to rigid specifications. Here you see it just about ready for shipment to the customer. Shipping weight, approximately 7800 lb.

This is a good example of the medium-sized forgings that Bethlehem is equipped to make. But if you need smaller pieces, Bethlehem can easily furnish them (drop forgings, for example, weighing as little as a pound). And our shops also make the largest forgings ever required—some weighing more than 100 tons.

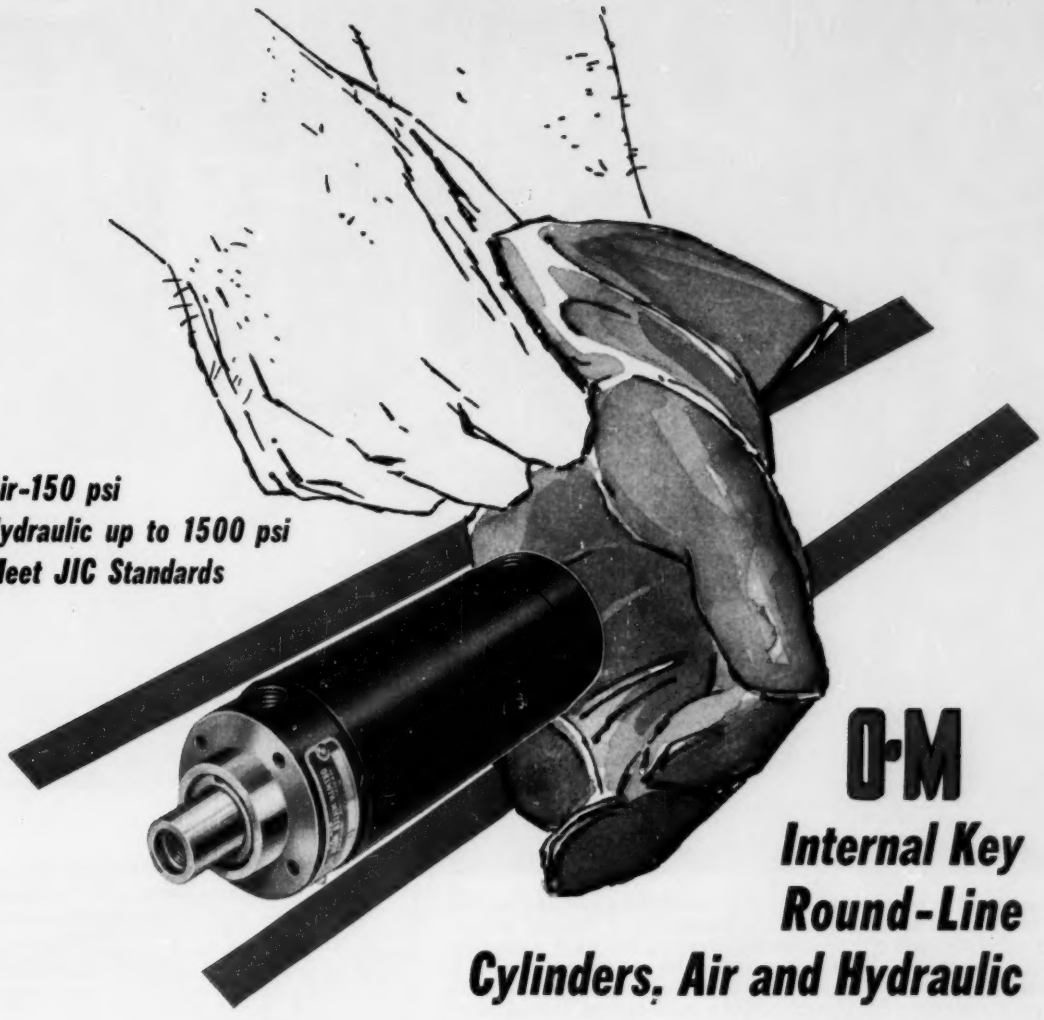
Call us when we can be of service to you or members of your staff. Our engineers will gladly cooperate, from the planning stage to the finished product.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



Air-150 psi
Hydraulic up to 1500 psi
Meet JIC Standards

O-M
Internal Key Round-Line Cylinders, Air and Hydraulic

Fit like a hand in a glove where space is limited

THAT'S why this O-M original Round-line of Cylinders, that fit where others won't, is widely specified by design engineers when space, weight and streamlining are important.

There are other advantages in using these powerful, compact components. For example, they are of all-steel construction with bearing surfaces of bronze, have the lowest coefficient of friction of any cylinder, and deliver continuous, smooth, dependable power at low or high speeds.

In addition, they are simple to install and service. The end plugs are tapped for universal mounting, and the ports can be oriented to any position. These cylinders are quickly and easily modified to fit special applications.

Available in a complete range of sizes (1½" to 8" bores) with standard 2 to 1 or oversize rods. Also full line of mounting brackets interchangeable bore for bore. Immediate delivery on many sizes.

Write today for catalog 101A.

ORTMAN MILLER MACHINE CO.
7 143rd Street, Hammond, Ind.

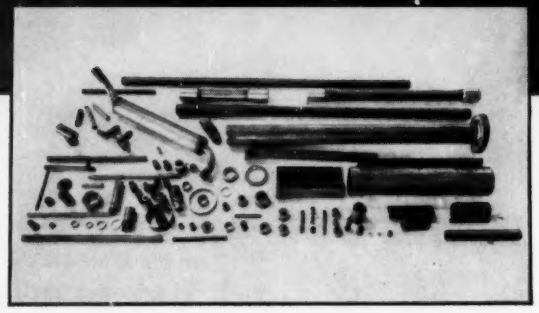
- ☐ Have representative call
- ☐ Send Bulletin 101A

Name_____ Position_____

Company_____

Address_____

City_____ Zone___ State_____



Seven-million miles of street and industrial sweeping in 700 cities have proved rugged dependability of Wayne Manufacturing Company's equipment. Here is the final assembly line in its plant. Large horizontal tube on sweeper is jack shaft housing for gutter broom drive. Wayne makes 300 parts from Pittsburgh Steel's Seamless cold-drawn tubing (see inset at right). That's how . . .

Pittsburgh Steel Seamless Tubes Help Wayne Make Clean Sweep

Nobody knows how many brooms it would take to keep the world clean. But out in Pomona, California, Wayne Manufacturing Company is ready to tackle the job with a complete line of power sweepers.

Founded only ten years ago, the Wayne Company has grown rapidly until today it produces more street and industrial power sweepers than all others in the field combined. Wayne is the only power sweeper produced by assembly-line operation.

Largest Wayne sweepers handle up to four cubic yards of debris at a time. Their assembly requires more than 1,000 complicated and accurately manufactured steel parts.

• **300 Key Parts**—Of these, more than 300 key items are fabricated from Pittsburgh Steel Company's Seamless Tubing in both carbon and alloy grades in sizes ranging from one-quarter inch to six inches in diameter. It is furnished cut to length and ready for fabrication by Baker Steel & Tube Company of Los Angeles, a Pittsburgh Steel distributor.

This service helps speed Wayne production, keeps inventories down and is typical of service rendered by all Pittsburgh distributors.

"Requirements for the parts produced from Pittsburgh tubing are exacting," says Wayne production vice-president, Roy E. Nelson. "Our sweepers are doing big jobs, many of them operating on a 24-hour schedule, and we

must have a tough, dependable product in the critical spots to take this constant heavy beating."

That is why Wayne uses Pittsburgh Seamless Tubing in critical components such as rugged axle assemblies, torque housings, drive shafts, hydraulic actuating cylinders—even small fittings.

Over the years, Wayne production men have found Pittsburgh tubing has the surface finish, close size tolerance and concentricity which minimize the amount of machining that must be done. Its uniformly high physical properties and internal soundness provide the stamina necessary for long, trouble-free service.

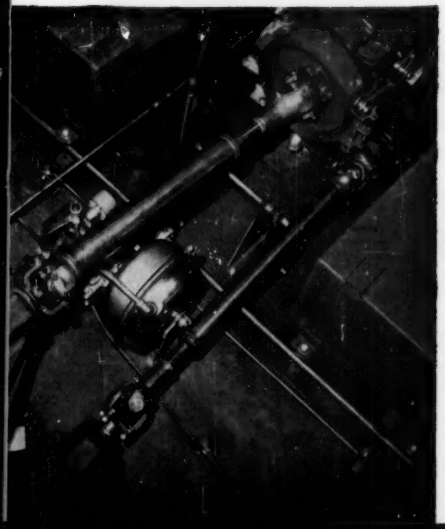
• **Ease of Fabrication**—The machinability and weldability of Pittsburgh tubing make for ease of fabrication, keep scrap losses down, and assure uniform parts—all important factors in keeping production lines moving smoothly.

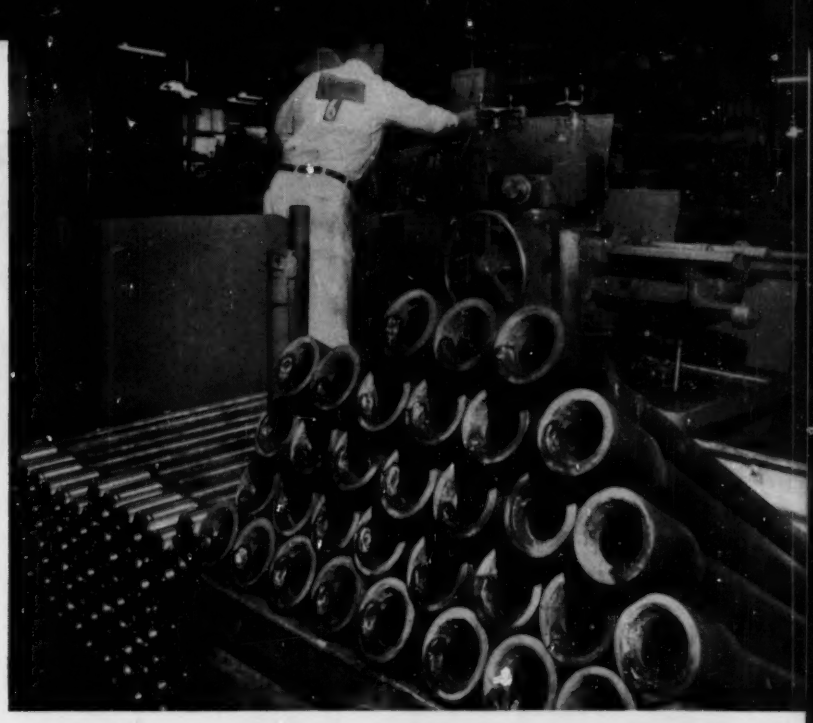
As an aid to industrial good housekeeping, Wayne produces smaller power sweepers for use inside and outside plants. Its newest line is the Autoette series which includes the glamorous "Golfmobile" and the family "Cruise About." Three industrial models provide efficient transport of personnel and materials in sprawling plants.

These industrial sweepers and Autoettes also depend upon Pittsburgh Steel tubing for parts in key assemblies.

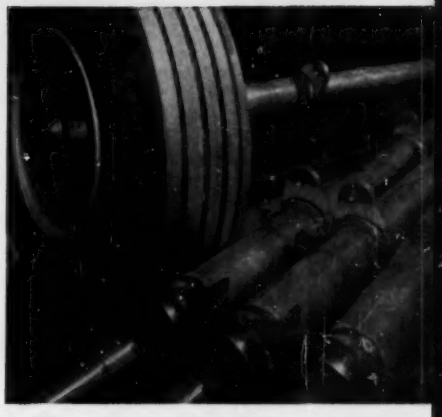
Manufacturers find the uniformly high quality of Pittsburgh cold-drawn steel seamless tubing and excellent service from Pittsburgh distributors are big assets in improving products and operating efficiency. To enjoy these benefits get in touch with the representative nearest you.

Pittsburgh tubes withstand torque and fatigue in main and auxiliary drives on Wayne sweepers.





Machinability and weldability of Pittsburgh tubes are vital in making this shaft which goes into differential assembly. Short tube is welded over longer, smaller diameter tube, then machined to tolerance of .001 inch to assure perfect fit in housing.



Rugged front axle assembly of Wayne sweeper made from Pittsburgh tubes carries most of weight of machine and up to four cubic yards of debris. It must withstand road shocks and constant heavy-duty operation.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
San Francisco, California

Earle M. Jorgensen Co.

Perry Kilsby, Inc.
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois

Solar Steel Corporation
Cleveland, Ohio

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

District Sales Offices

Atlanta, Chicago, Cleveland, Dallas, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

Circle 469 on Page 19

DESIGNS THAT WORK START WITH Best

SYNCHRON®

TIMING MOTORS

Precision-engineered SYNCHRON synchronous motors operate smoothly, efficiently in any position at temperatures from —40°F to + 140°F . . . start instantly under load . . . pull up to 20 in. oz. at 1 r.p.m. Speeds from 0.8 r.p.m. to 600 r.p.m.

UL and CSA approvals

BUILT FOR PERFORMANCE

1 PATENTED TWO-PIECE FIELD STRUCTURE

2 DOUBLE BEARINGS in reduction train

3 ALUMINUM ROTOR RING SUPPORT.

4 PATENTED, HARDENED STEEL ROTOR RING.

5 OIL STORAGE RESERVOIR with patented oil feed to bearings.

6 HEAVY BRASS ROTOR COVER.

7 DOUBLE BEARINGS ON OUTPUT SHAFT.

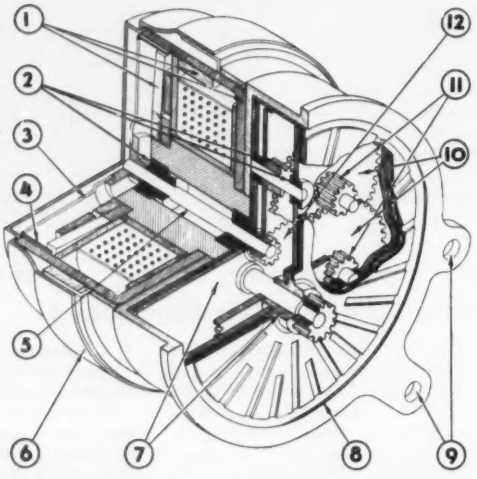
8 GEAR CASE SEALED against oil leakage to permit mounting in any position.

9 FOUR CONVENIENT MOUNTING HOLES.

10 BRASS GEARS.

11 STEEL PINIONS.

12 BAKELITE GEAR for quiet operation.



a SYNCHRON® for every requirement

STANDARD TIMING MOTOR (8 IN. OZ.)
Compactly built to space saving dimensions, with rotor and coil packed in a sturdy hand-sized case. Used in timing devices and controls of all types. Guaranteed torque 8 in. oz. at 1 r.p.m.

HI-TORQUE TIMING MOTOR (20 IN. OZ.)
There's big power packed into this versatile timing motor. One year guarantee. Dependable, accurate, trouble-free. Guaranteed torque 20 in. oz. at 1 r.p.m.

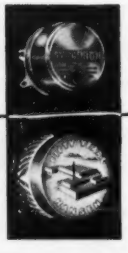
SLO-MOTION TIMING MOTOR
Versatile new pear-shape timing motor developed especially for replacement application. 110 speeds available within ½ r.p.h. and 360 r.p.m.

HANSEN CLOCK MOVEMENTS
For standard and office clocks, sign clocks, novelty clocks, and clocks of all kinds up to 26" in diameter under glass. Precision power with a Synchron timing motor.

HANSEN MAGNA-TORC DC MOTOR
Designed for aircraft instruments and radio controls. Armed Forces applications have proved its top performance world-wide under all operating conditions. Easily adapted to commercial uses.

WRITE FOR NEW ILLUSTRATED BROCHURE OF FULL SYNCHRON LINE OR SEE IT IN SWEET'S FILE OF PRODUCT DESIGN

SYNCHRON®



"Workhorse of the industry"
synchronous motors, timing machines, clock movements, magnatorc DC motors

h¹

HANSEN MFG. CO., INC.
OUR 50TH YEAR

Princeton 12, Indiana

FOR FULL INFORMATION CALL OR WRITE TODAY

HANSEN REPRESENTATIVES: The Fromm Co., 5150 W. Madison St., Chicago, Ill.; Winslow Electric Co., New York, N.Y., Chester, Conn., Philadelphia, Cleveland; Electric Motor Engineering, Inc., Los Angeles WEBSTER 3-7591 and Oakland, Calif.; H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton and Schenectady, New York

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

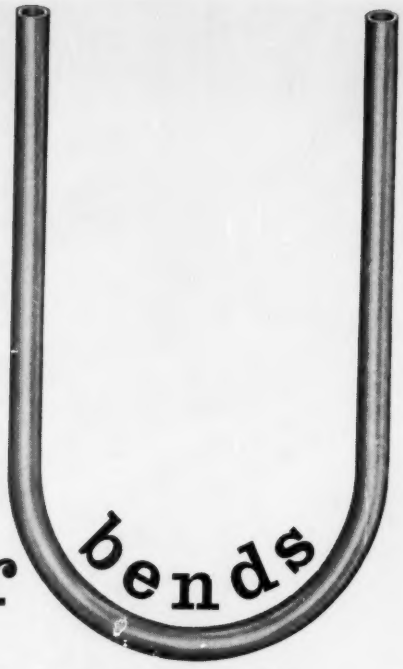
8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

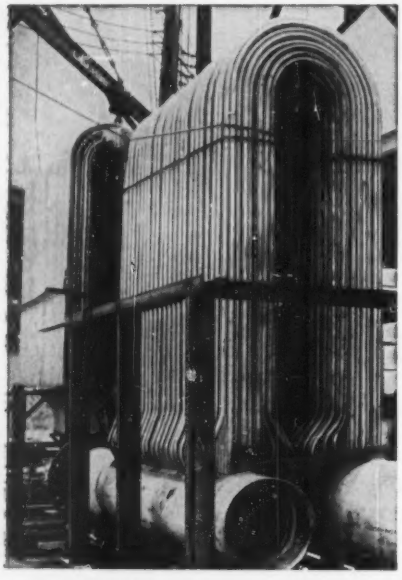
10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

1600 Carpenter bends



harness 2,000,000 lb. of corrosive hot air per hour



Conventional stainless steel tubing couldn't do the job. Six miles of tubing was needed, 1600 U-bends for a four-stage heat exchanger that raises 560 pounds of air from 350° to 700° F *each second.* The exchanger, one of the largest ever built, is being used in a gas-turbine aircraft engine test program.

The problems were carbide precipitation and loss of corrosion resistance due to the operating temperature. The problems were eliminated easily . . . with Carpenter Type 321 welded and cold drawn stainless tubing stabilized with titanium.

When something extra in uniformity, economy and low-cost service is needed, you'll benefit by contacting the Carpenter distributor or representative in your area. For complete data on the many analyses of Welded Stainless Tubing and Pipe available from distributor stocks or our mill, write for Bulletin T.D. 120 on your company letterhead. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.—The House of Corrosion Control.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

your master key to cost-saving corrosion control

stainless tubing & pipe

Comparative tests prove *Norgren* AIR LINE FILTERS SAVE MAINTENANCE TIME

MAKE	NORGREN	A	B	C	D	E
LOOSE PARTS TO DISASSEMBLE	4	9	15	13	6	12
TOOLS REQUIRED FOR MAINTENANCE	NONE	Wrench	Wrench & Screw-driver	Screw-driver	Wrench	Wrench & Pliers
TOOL OPERATIONS REQUIRED	NONE	2	10	16	2	4

No Tools Required... Fewer Parts to Handle

Compare Norgren with other makes of manual drain filters. All others require tools to take them apart ...then there are a dozen or so loose parts—easily dropped and lost, and likely to be improperly reassembled. Not so with Norgren Filters. No tools are needed for maintenance and there are only four parts to reassemble. Maintenance is simple... an easy job for anyone. This means a big saving in maintenance time and money.

Norgren Filters Provide Top Performance in removing damaging solids and liquids from an air line. Transparent or metal bowls. ¼", ⅜", ½", ¾", 1" pipe sizes.

If it's Norgren... It's Dependable.

For complete information, call your nearby Norgren Representative—or WRITE FOR DESCRIPTIVE LITERATURE

C. A. NORGREN CO.

3442 SO. ELATI STREET • ENGLEWOOD, COLORADO

Circle 473 on Page 19

Standard microsize UNBRAKO socket cap and set screws, #0 through #3, are supplied by your authorized industrial distributor in heat-treated alloy or stainless steel. Available with Nylok* self-locking feature.

Microsize UNBRAKO Socket Screws Simplify Fastening of Small Assemblies

Microsize UNBRAKO socket cap and set screws save both time and money in the design and assembly of your small devices. Precision manufactured, available locally, they eliminate the cost and delay of designing or procuring special screws to fasten tiny components. Use them in computers, servomechanisms, instruments, miniaturized electrical and electronic equipment—countless small, intricate devices where reduction in weight and bulk is required without sacrificing strength or reliability.

These miniature socket screws have all the advantages of larger UNBRAKOS. Deep, accurate sockets for non-slip, high-torque wrenching. Radii in socket corners to eliminate sharp angles where cracks start. Fully formed threads for greater strength and precision fit. Controlled fillets under cap screw heads to prevent shearing. Careful heat treat for maximum tensile values without brittleness or decarburization. Because of these features, microsize UNBRAKO socket cap screws are as much as 80% stronger than ordinary miniature cap screws, and microsize UNBRAKO socket set screws can be torqued tighter than ordinary miniature set screws. This extra strength means greater reliability in the fastening of your small assemblies.

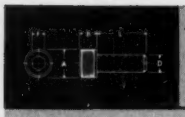
For more information, see your authorized SPS distributor. He carries microsize UNBRAKOS in both alloy steel and stainless in sizes #0, #1, #2 and #3. Or write us for Bulletin 2374 and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

*T.M. Reg. U.S. Pat. Off., The Nylok Corporation

We also manufacture precision titanium fasteners / *write for free booklet*

SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.



HEAT-TREATED ALLOY STEEL
Microsize UNBRAKO Socket Cap Screws
Class 3A Threads

Diameter		Threads per Inch NC	Threads per Inch NF	Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per 1000 in Pounds
#0	A .096		80	1/8		2.0	.21
	B .060		80	3/16		2.0	.22
	D .060		80	1/4		2.0	.26
	F .050		80	3/8		2.0	.33
#1	A .118		72	1/8		3.5	.31
	B .073		72	3/16		3.5	.36
	D .073		72	1/4		3.5	.42
	F .050		72	3/8		3.5	.53
#2	A .140	56		3/16	6.0		.54
	B .086	56		1/4	6.0		.61
	D .086	56		3/8	6.0		.76
	F 1/16	56		1/2	6.0		.91
#3	A .161	48		3/16	8.5		.77
	B .099	48		1/4	8.5		.87
	D .099	48		3/8	8.5		1.07
	F 5/64	48		1/2	8.5		1.27

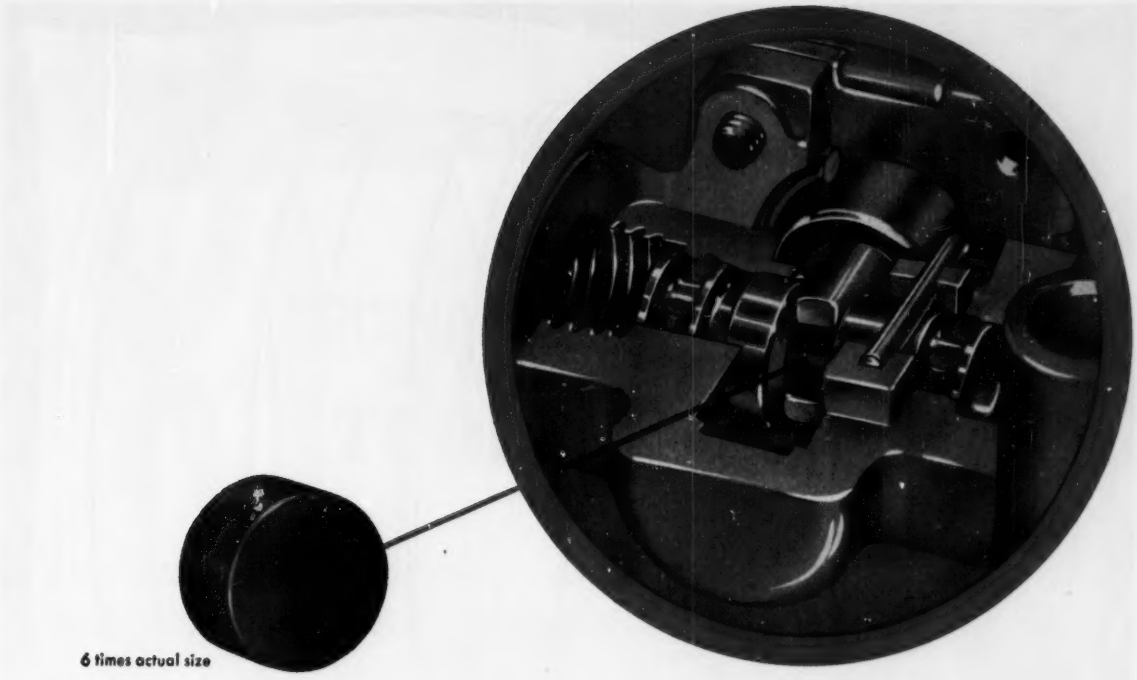
HEAT-TREATED ALLOY STEEL
Microsize UNBRAKO Socket Set Screws
Class 3A Threads—Plain Cup Point

Diameter		Threads per Inch NC	Threads per Inch NF	Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per 1000 in Pounds
#0	D .060		80	1/16		.5	.03
			80	3/32		.5	.04
			80	1/8		.5	.05
	F .028		80	5/32		.5	.06
			80	3/16		.5	.08
			80	1/4		.5	.11
#1	D .073		72	1/16		1.5	.04
			72	3/32		1.5	.06
			72	1/8		1.5	.08
	F .035		72	5/32		1.5	.11
			72	3/16		1.5	.13
			72	1/4		1.5	.19
#2		56		1/16	1.5		.05
		56		3/32	1.5		.07
	D .086	56		1/8	1.5		.107
	F .035	56		5/32	1.5		.15
		56		3/16	1.5		.19
		56		1/4	1.5		.273
#3		48		3/32	5.0		.10
	D .099	48		1/8	5.0		.135
	F .050	48		5/32	5.0		.18
		48		3/16	5.0		.235
		48		1/4	5.0		.32

HIGH RELIABILITY

SPS research is continually developing fasteners with higher and higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase your overall product reliability.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."



6 times actual size

FOR PRECISION OPERATION

VALCOR solenoid valve relies on a self-lapping GRAPHITAR® disc.

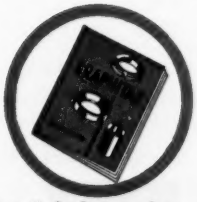
(CARBON-GRAPHITE)

These solenoid valves manufactured by Valcor Engineering Corp. of Kenilworth, New Jersey, incorporate a "floating seal" of GRAPHITAR, and are helping to launch the new age of guided missiles in America. Over half a million Valcor valves are in use in military aircraft and guided missiles today.

The heart of the "floating seal" solenoid valve is a precise, optically flat, GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. The solenoid valve actually improves with use, due to its unique self-lapping action.

GRAPHITAR has many unusual properties that make it an ideal material for such challenging applications. It is nonmetallic; resists chemical attack; is mechanically strong, yet extremely light in weight. GRAPHITAR will not warp and extreme changes in temperature cause virtually no expansion or contraction. Probably the most important of GRAPHITAR'S advantages are its self-lubricating properties and low coefficient of friction.

Today design engineers are solving many different problems by using GRAPHITAR, a most unusual and versatile engineering material. Perhaps GRAPHITAR is the perfect material for your product. Our competent staff of engineers can assist you in applying GRAPHITAR to your particular needs.



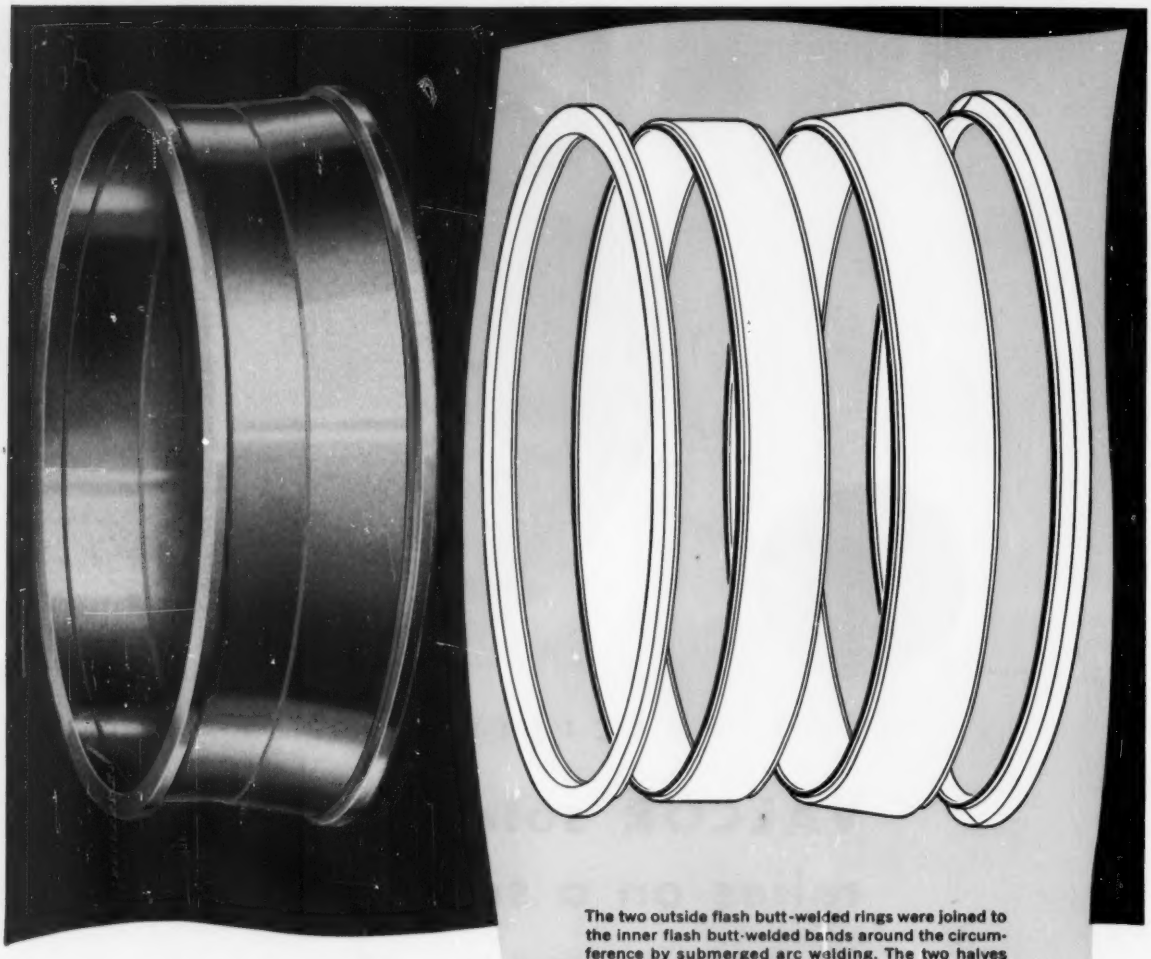
Detailed design data with typical applications, properties and characteristics of GRAPHITAR, are included in Bulletin #20. Write us today—on your letterhead —for a free copy.

R-258-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



The two outside flash butt-welded rings were joined to the inner flash butt-welded bands around the circumference by submerged arc welding. The two halves were then welded together to complete the assembly.

Tricky

Welded Fabrication Cuts Cost of this Precision Assembly

To reduce material and machining time, Amweld® produced this 340 lb. turbine casing as a 4-piece welded assembly. Four flash butt-welded rings were joined together by submerged arc welding. The material used was AMS-5723, a high temperature alloy. Amweld's know-how, gained from fabricating hard-to-weld metals, enabled their engineers to develop a satisfactory technique for producing these aircraft components in quantity. The result — assemblies which met all specifications — and a substantial reduction in cost for a large manufacturer of aircraft engines.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you — phone or write today. Our local representative will be happy to call and discuss your requirements.

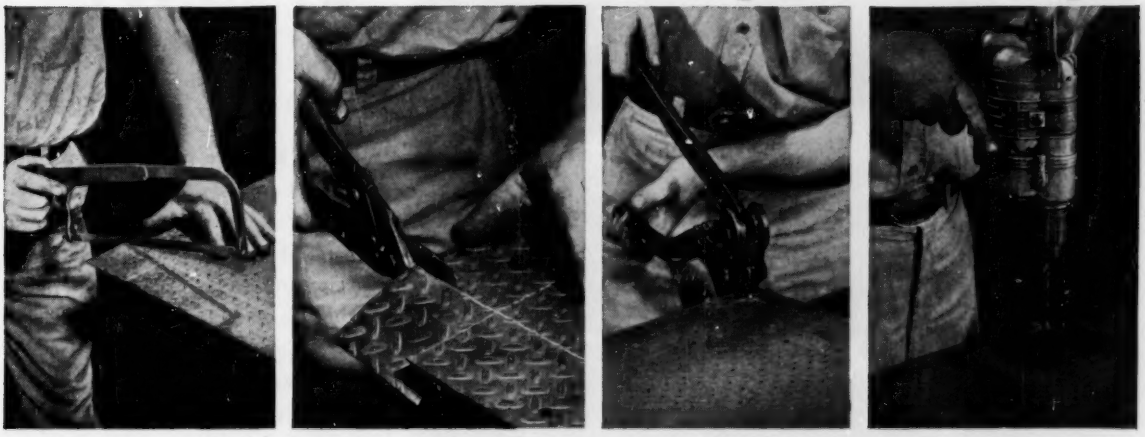
HOW AMWELD® FLASH BUTT-WELDED RINGS ARE PRODUCED. Write today for new 20-page illustrated booklet.

THE AMERICAN WELDING & MANUFACTURING CO.

130 Dietz Road • Warren, Ohio

AMERICAN WELDING

can cut, bend, hammer, drill, shape, roll saw, snip



SMALL PATTERN INLAND 4-WAY® SAFETY PLATE

You don't have to spend a penny for special equipment. With just the normal tools available in your plant you can work with Small Pattern Inland 4-WAY SAFETY PLATE—use it for dozens of maintenance jobs.

Small Pattern 4-WAY SAFETY PLATE is only 18 gage, weighs only 2.4 pounds per square foot, yet has all the slip-resistant traction and safety features that has made regular 4-WAY SAFETY PLATE famous. Small Pattern 4-WAY costs less to use—less per square foot covered—than other similar materials.

It's tough, rugged, built for years of wear, yet it is light and flexible enough to carry wherever needed—work into any required form. Try it. It's firesafe, non-absorptive, easy to keep clean—the ideal material for fast, easy, low-cost maintenance use.

a few of the ways you can use light gage Safety Plate:

kick plates
tool racks
wall covering
treads on wood steps
round or square column protectors
thresholds
truck beds
resurfacing
machines tool tables
covering over worn cement stairs

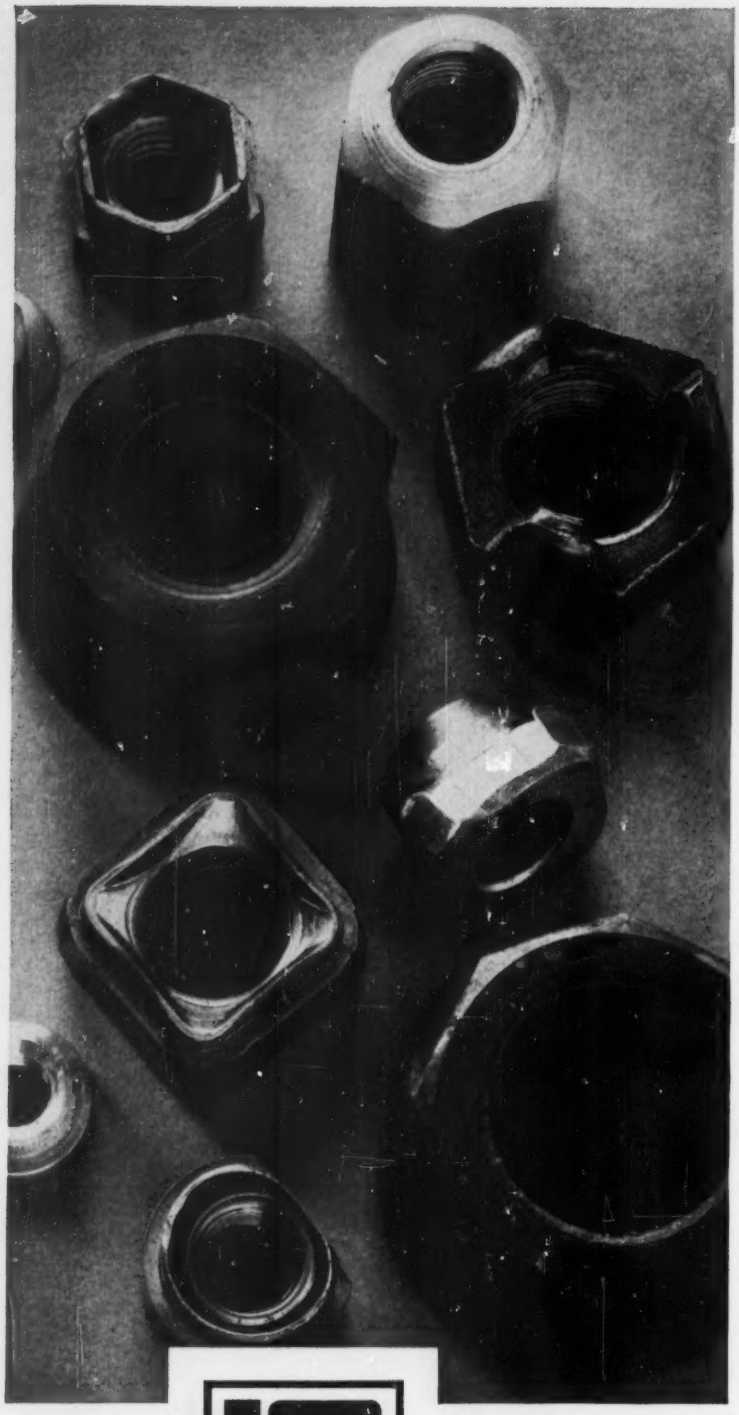
AVAILABLE FROM YOUR STEEL SERVICE CENTER in 18 gage, cut to your needs in widths up to 42" and lengths up to 152".

AMERICAN STEEL WAREHOUSE ASS'N.

INLAND

4-WAY SAFETY PLATE
® Registered U. S. trademark

INLAND STEEL COMPANY
30 West Monroe Street, Chicago 3, Illinois



A nut is a nut... or is it?

At L & S, we produce hundreds of special nuts to customer specifications... a few of which are shown here. Many times our engineers develop the design—to meet a customer's specific fastening problem. Need a special-purpose nut or other fastener that doesn't exist? We have the know-how *and* the equipment to design it, produce it, economically!... Send us your prints or problems.

L & S Fastener Engineering helps you "tighten up" on assembly costs

LAMSON & SESSIONS

5000 TIEDEMAN ROAD • CLEVELAND, OHIO

Plants in Cleveland and Kent, Ohio • Chicago and Birmingham

Circle 477 on Page 19

MACHINE DESIGN

January 8, 1959

Toward Management Status

THE engineering team had done a superb job of redesign. On actual test, efficiency of the pump was up twenty per cent. Production cost could be reduced a fantastic forty per cent. And an artistic job of restyling gave the job a sleek, modern appearance that suggested power and durability.

It was a proud day when the new design was unveiled before top management. Alas for the engineers' hopes of a pat on the back, a few raises, and some new equipment! Only then did they learn that demand for the particular service which the pump performed was currently satisfied, and that no expansion of its market was likely.

The waste of time and effort, and the blow to engineering department morale, could be blamed on top management. It failed to inform the engineers of the current status of the company's "product portfolio."

But the engineers were equally at fault for not looking beyond their immediate technical problems to the broader implications of their work. An awareness of the significance of such things as market changes and the competitive situation would have prompted a few inquiries. As it was, a sincere effort backfired.

Engineers generally regard themselves as part of management. They can earn the right to be so regarded by top management only in proportion to their awareness of corporate problems—and their effectiveness in taking proper action. MACHINE DESIGN's articles on product planning subjects, such as Phil Marvin's in this issue, are presented in the hope that they will help engineers qualify themselves for true management status.

Colin Carmichael

EDITOR

Is each of the company's products really making money

Are any approaching obsolescence

How many new-product ideas are in the mill

Will the new products fit into overall future plans

?

Answers to such questions clear the way for intelligent decision — and effective engineering. They can be obtained only through continuous appraisal of the "product portfolio."

IT CAN'T be emphasized often enough—the only reason for being in business is to produce products at a profit. The products on which profits are based deserve more attention than they usually receive. Prosperity and growth are results of soundly planned product "portfolios," reflecting a smooth flow of products throughout the various phases of the process of creating, producing, and distributing products.

It isn't enough to create products. These individual products must fit into product portfolios. These portfolios, in turn, must be re-examined to evaluate the effect of new products on older products and to sense both needs and opportunities.

For effective appraisal of product portfolios, the whole product spectrum must be scrutinized, from the beginning of the product cycle with the creation of product ideas through each step to the final sale. Increasing technological complexity of the contemporary industrial scene and growing intensity of competition that surrounds its products demand that those responsible for the development of new products accept also the responsibility for assuring balanced portfolios.

Where is the starting point? The admission by one engineer that he had been under severe criticism for concentrating on products that were troublemakers rather than those that were profit producers reflects the misplaced emphasis frequently encountered. In filling the role of troubleshooter, engineers can and should provide the type of leadership and direction to product programming that prevent problems from arising by eliminating them at their source.

Errors of judgement are too common. The only sure way to know where to concentrate efforts is through continuing analysis of the company's product portfolio.

Developing a
Plan of Attack

The basic ingredient of success in any undertaking is a well-organized plan of attack. To reveal strong and weak points in different product lines, performance of individual product lines must be examined separately.

A company's image in the eyes of its customers is usually established on a product-line basis. The multiple-plant manufacturer in the electrical industry may be a producer of household appliances to one group of customers, and construction materials to another. The large machinery company, similarly, may be a supplier of automatic lathes to one and textile machines to another. To strengthen product programs the customer-centered product line offers the starting position.

To point up fundamental facets of product-line analysis, the accompanying case study, *Troubleshooting A Product Program,* reconstructs a typical situation. The problem faced at the close of the fiscal

By PHILIP MARVIN
Division Manager, Research and Development
American Management Association
New York, N. Y.

Auditing product programs

year by a hypothetical company will serve to illustrate the way in which a product portfolio can be thrown into significant perspective.

Balancing a
Product Line

Favorable or unfavorable returns from a product line over any significant span of time reflects the degree of balance achieved in the portfolio of products identified as the product line. At a given time, a low return on invested capital in a particular product line may be due to the introduction of new products to strengthen the line. Another cause of poor returns may be the fact that one or more products have become obsolete but are being carried until replacements can be generated. These and other circumstances may justify a low return on invested capital. Unusually high returns are attributable to equally transitory factors.

To analyze individual product lines, each product in production, as well as those in development and predevelopment phases, should be positioned with respect to its own individual life cycle, and with respect to the basic objectives of the product offerings of the business.

The composite picture reveals the degree to which the company is meeting objectives and protecting future earnings by assuring a continuing supply of new products to replace those becoming obsolete. It also reveals the degree to which a company is taking full advantage of opportunities to introduce lower-cost products and restyled items, as well as those designed for improved performance, new markets, and new uses.

Synchronizing
Product Efforts

In the life cycle of a product, ten distinct phases are recognizable. These include five pre-market categories,

1. Prospective
2. Speculative
3. Potentially Profitable
4. Scheduled
5. Developmental

and five in-market categories,

1. Introductory
2. Growth
3. Competitive
4. Obsolescent
5. Drop-out

One of the important indicators of a soundly planned program is the presence of several or more products in each phase. The fundamental importance of each of these individual phases to overall profits will be reviewed, starting first with the competitive

phase of their life cycle.

Competitive Phase: In most companies it would be expected that the bulk of the product effort would be classified in the competitive phase. These products would be well-established in markets that would have proved attractive. As a consequence of this attractive market, others in the industry would have similar product offerings.

Troubleshooting A Product Program

. . . details of a typical product-portfolio analysis

At the close of the fiscal year, sales of the XYZ Co. had increased steadily to a peak figure of $80,241,000. Contrasted with increased sales, after-tax profits were less than 6 per cent. This was the poorest profit position company management had ever faced. To isolate factors contributing to declining profits, the performance of individual product lines themselves will be examined. Comparing individual product lines on the basis of their capacity to produce profits provides insight in interpreting profit trends.

Income Analysis: Overall product program of the company is built around ten basic product lines. Sales, profits and other significant data for each product line are summarized in *Income Analysis by Product Line*. Analysis of profits by these individual product lines is a basic management control, each product line being revealed as a profit producer or profit reducer. This analysis tells where to concentrate efforts in improving the overall profit position.

Overall profits of the company for the year are 5.4 per cent of sales. Product line D is the most profitable, six product lines show losses, three contribute negligible returns.

Each product line makes use of company resources which should be deployed in the most productive manner. Here, more than half of the funds are seen to be unprofitably invested. Over 45 per cent of the company's money is invested in product lines producing an unattractive return. In sharp contrast, the funds invested in a single product line produced the unusually favorable return of 45.3 per cent on that investment.

Product-Portfolio Analysis: Finding the problem areas will require a more probing analysis of each basic product line. To illustrate this approach, product line A will be examined in detail here. Product-life phases will be considered in the same order as discussed in the article text.

Product line A consists of a group of the company's mechanical goods, centering around a line of reel-type mowers and including certain other auxiliary products to round out the product portfolio. Product life-cycle relationships in this product line are depicted in chart form in *Product Program Analysis*.

COMPETITIVE: Four models of reel-type mowers are currently regarded as being in the competitive phase. These are models 72, 36, 85, and 29. They are positioned in the chart with respect to their own individual life cycle. Collectively, these four products account for a net income of $60,000. The net income attributable to each individual product is shown by the solid black bars in the lower section of the chart, just below the individual model. Figures at the top of each bar show the specific amount in thousands of dollars. For example, an $18,000 net income is allocable to the model 72 mower.

OBSOLESCENT: Two products are classified in the obsolescent phase: Models 10 and 15 reel-type mowers. Together, they represent an income of $15,000.

DROP-OUT: Products classified in the drop-out phase account for $9,000 of the net profit from sales.

INTRODUCTORY: New product offerings by the company cut across the range of competitive opportunities.

Lower Cost: Model 210 rotary mower is a redesign of the Model 190 rotary and provides a comparable product at a lower cost, reflected in the selling price of the new items.

Restyling: Model 320 reel-type mower, which is being introduced to the market, represents a restyling of the Model 6 reel unit, which is scheduled for drop out.

Improved Performance: The Model 608 reel-type mower represents a re-engineering of the Model 15 reel unit which is classified in the obsolescent phase. A drop-out date has not yet been scheduled for the Model 15.

New Markets: An attempt is being made to enter new markets having different seasonal characteristics. Snowshoes and sleighs are being added to the line to provide items in the product portfolio which will have off-seasonal characteristics. Both snowshoes and sleighs have seasonal patterns running directly counter to the products in the present line, all of which are used during the summer.

New Uses: Prior work with lawn mowers gave the company's engineers the experience needed to extend the usefulness of this product to leaf mulching.

Products in the introductory phase represent an outlay in

Income Analysis by Product Lines

Product Line	Share of Market	Sales Volume		Manufacturing Costs		Administrative and Sales Costs		Profit or Loss			Capital Investment		Turnover of Investment†
	(%)	($1000)	(% of total)	($1000)	(% of total)	($1000)	(% of total)	($1000)	(% of sales)	(% return on investment)	($1000)	(% of total)	
A	8	3,600	4.5	3,052	4.6	497	5.1	51	1.4	3.2	1,593	4.1	2.3
B	7	9,845	12.3	9,694	14.6	1,592	16.4	−1,441	−14.6	−49.6	2,903	7.5	3.4
C	12	9,700	12.1	8,228	12.4	1,700	17.5	−228	−2.4	−3.8	5,990	15.6	1.6
D	21	36,900	46.0	26,356	39.8	3,388	34.8	7,156	19.4	45.3	15,800	41.0	2.3
E	16	4,845	6.0	4,030	6.1	909	9.3	−94	−1.9	−11.5	819	2.1	5.9
F	14	2,200	2.7	1,851	2.8	347	3.6	2	.1	.1	1,795	4.7	1.2
G	18	1,975	2.5	1,829	2.8	141	1.4	5	.3	.4	1,259	3.3	1.6
H	15	5,925	7.4	5,587	8.4	513	5.3	−175	−3.0	−4.3	4,033	10.5	1.5
I	11	2,950	3.7	3,327	5.0	368	3.8	−745	−25.3	−26.9	2,774	7.2	1.1
J	8	2,301	2.8*	2,226	3.5*	280	2.8*	−205	−8.9	−13.3	1,540	4.0	1.5
	Total	80,241	100.0	66,180	100.0	9,735	100.0	4,326	5.4	11.2	38,506	100.0	2.1

*Adjusted to total 100%. †Ratio: Sales volume/capital investment.

Prices and profits would normally have reached rather well-defined upper limits as the opportunity for exploitation of the market was curtailed and opportunities to reduce costs through greater volume became more difficult. The competitive phase of a product's life would normally reflect a growth of volume and profits followed by a leveling off and some mild decline.

Obsolescent Phase: Products should be regarded

excess of income of $7,000. Two of the products yield a profit of $23,000 but this is offset by the $30,000 outlay for the four remaining products in the introductory phase. It should be expected that products in this category will not show a profit. This is a market development phase.

GROWTH: Five products have entered the growth phase: A snowblower, a tractor, two reel-type mowers, and one rotary mower. In the current period shown in the chart, each of the five major competitive opportunities discussed previously are being exploited by products in the growth phase. This reflects the fact that considerably greater attention is being paid to product development in current periods than was the practice in earlier years. From a study of the classification of older products in the competitive, obsolescent, and drop-out periods it is apparent that no attention was given to products for new markets or new uses. Primary emphasis was in the single direction of performance improvements in existing models with one attempt at restyling and one at design for lower cost.

Products in the growth phase currently yield an annual return of $38,000. Growth in sales is anticipated for each of these five items. The net return is expected to exceed $100,000 within a short period of a few years. New product development is not only making substantial contributions to the profits of the company but is broadening the profit base, and contributing to stability.

Turning now from the in-market categories to the pre-market items gives a further insight into the long-range strengths and weaknesses of the company's product program.

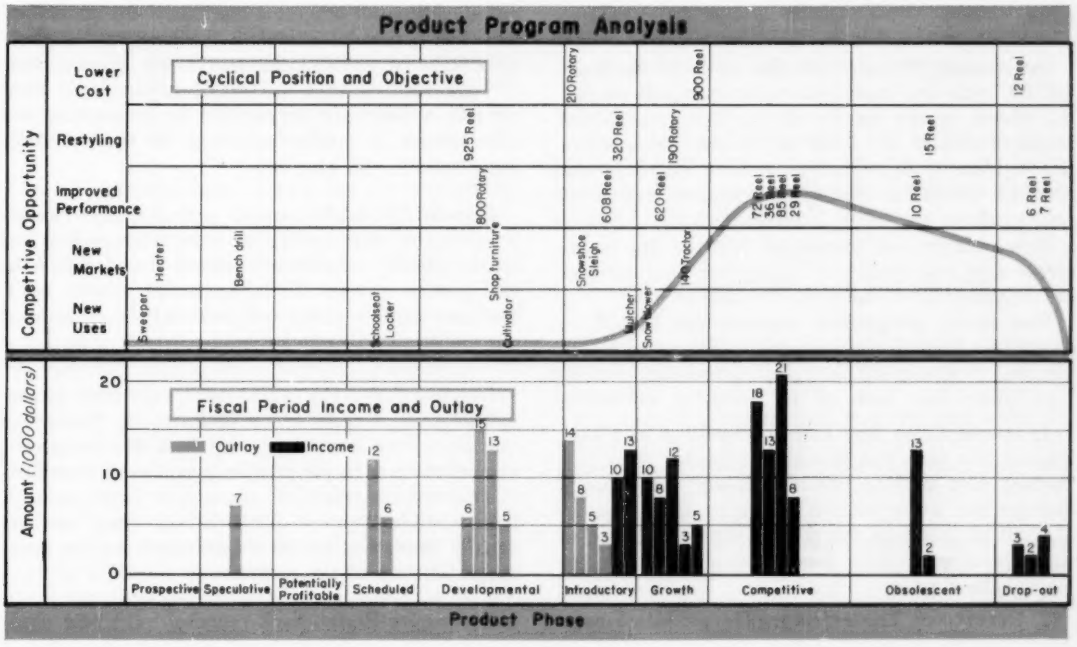
PROSPECTIVE: In this program, there is a relative dearth of new ideas awaiting appraisal. Both a driveway and sidewalk sweeper have been proposed, as well as a workshop heater, but ideas for lower costs, restyling, and improved performance are noticeably lacking.

SPECULATIVE: The company has already spent $7,000 in evaluating a bench drill that would enable the company to enter new markets. As yet, available evidence is inconclusive as a basis for either accepting or rejecting the proposal.

POTENTIALLY PROFITABLE: Analysis of this product portfolio shows that there are no unscheduled proposals. Those ideas that have appeared to be potential profit producers have been scheduled. Other than to accommodate the normal time required to process an idea into the development schedule, there isn't any good excuse for a backlog of unscheduled projects. Even though it may not be feasible to commence work on a project for several years, it should be scheduled. This in itself will call management's attention to the need for action to relieve the backlog of scheduled projects.

SCHEDULED: Two projects are in the scheduled phase, a school seat and a locker. An expenditure of $18,000 has been allocated to these two proposals. This money was actually disbursed in evaluating the merit of these respective proposals. Since the proposals themselves have moved into the scheduled phase, expenditure figures move with them.

DEVELOPMENTAL: Four products are under development, a cultivator, shop furniture, a rotary mower, and a reel mower. An outlay of $39,000 has covered this development work during the period under review. It should be noted that no attention is being given to new products that will take advantage of cost-reduction opportunities in the present program. This neglect could have rather far-reaching consequences in the event that competitors plan to capitalize on such opportunities.



as having passed from the competitive phase of their life cycle into the obsolescent phase when a pronounced downward trend in sales volume is clearly indicated. For as long a period as steps can be taken to prolong the time before this downward trend becomes established, products should be regarded as competitive. As soon as it becomes evident that all of the available resources that can be used to maintain healthy sales have become exhausted, it should be recognized that the forces of obsolescence have taken control of the situation.

Classification of a product in the obsolescent phase does not infer that there are no further profit opportunities inherent in the product offering. Profitable sales may be enjoyed for a considerable period of time after a product is classified in the obsolescent phase.

Steps should be taken to project the probable time at which individual products will become unprofitable. Dropping products from the line calls for careful planning. Dropping products merely because they are unprofitable may have very far-reaching effects on the sale of other products. Even though they are unprofitable, certain items, because they round out the total product line, should be carried until replacement items can be introduced.

Drop-Out Phase: Classification in the drop-out phase serves as a reminder to management that specific products have been assigned scheduled dates on which they are to be dropped from the line. In some instances, the date may be set 30 or 60 days ahead; in others the drop-out date may be set months ahead. The selling organization must prepare dealers and distributors for the discontinuance of these items. At the same time, this classification calls to the attention of those responsible for the product portfolio the necessity of scheduling replacement items that should be available prior to the scheduled drop-out dates.

Introductory Phase: In another phase of the product life cycle are those new products which are being placed on the market for the first time. These products should be classified in the introductory phase. Here it is important to note not only the products themselves but specific reasons why these new products are being introduced.

New products are introduced into the line to increase sales and profits and to replace products that are dropping out of the product portfolio.

Five major competitive opportunities should be capitalized upon by new-product offerings. Soundly planned programs should reflect new-product offerings falling into each of the following categories:

1. LOWER COST: Any redesign resulting in a substantial cost reduction should be regarded as an important new-product offering. Lower cost usually changes the profit position of the product either as a result of increased margin per unit of sales or as a result of potentially greater sales volume at the lower selling price.

2. RESTYLING: The redesign of a product, resulting in greater sales appeal and added consumer acceptance, is a major competitive opportunity for the introduction of a new product.

3. IMPROVED PERFORMANCE: Re-engineering existing products for improved performance or introducing newly engineered models featuring improved performance offer a fertile and commonly exploited area of competitive opportunity.

4. NEW MARKETS: Exploiting new markets may be accomplished by extending the usefulness of existing products into new areas or by introducing radically new products.

5. NEW USES: Another major competitive opportunity is that of adapting products to new uses. These new uses may represent an extension of the area of application of present products or they may represent a radical departure from existing products.

These five major competitive opportunities overlap and any consideration of the category of new uses provides an example of such overlap. But this is not a serious limitation of the system of classification because it forces product planners to stretch their imagination somewhat and the result can only be for the good. The category of new uses directs attention specifically to capitalizing on opportunities to extend the usefulness of present products.

Many products can be used for more than one purpose. Exploitation of these new uses increases sales. For example, the tongue depressor the physician uses in throat examinations can also be effectively used to mark the location of plants in the garden. Such extremes of usefulness apply in the case of many products. To detect these new uses, product planners must exercise both their ingenuity and imagination.

These five major competitive opportunities have been explored in some detail because they are important not only in planning new products but in auditing product programs once they are underway. The five categories stimulate thinking in the planning stage by calling attention to the full spectrum of opportunities that are open. Beyond this they provide a reference framework for measuring the effectiveness of product offerings in accomplishing these specific end purposes.

Growth Phase: As soon as a product has proved its ability to capture market acceptance and to increase volume saleswise, it should be classified in the growth phase. This is another reason why the introductory phase will seldom if ever show a net profit.

Dividing Line: Up to this point, only those phases in the product cycle where products are offered for sale have been considered. In these five categories, in-market items in the product portfolio are classified.

The second group of pre-market items is of a less tangible nature. Nevertheless, these are an equally important group of products from the long-range position of the company.

Prospective Phase: Each proposal for a new prod-

uct falls in the prospective phase until such time as it can be appraised. The products in the prospective phase form a stockpile of ideas which should be part of a continuing process of finding, screening, and appraising new ideas. Unless the hopper of new ideas is full at all times, the screening and appraising function grinds to a halt for lack of raw material. Once halted, this operation is hard to get going again. A healthy stockpile of unappraised ideas is a positive sign of a vigorous product-development program.

Prospective-product proposals should be found classified under each of the five major competitive opportunities previously discussed. Unfilled classifications on the chart (see case study) may reveal a lack of vigorous action on the part of those who hold the responsibility for developing ideas for new products.

Speculative Phase: In the process of evaluating product proposals, a preliminary screening eliminates those of little or no apparent value to the company. Those remaining should be classified as speculative. As such, they are subject to more intensive analysis of their value to the company.

Potentially Profitable Phase: Ideas that are appraised as potential profit producers should be placed with other proposals awaiting their turn on the development schedule. Positioning these in a special category calls attention to the fact that they have not been assigned a place in the development group's schedule. This is important. Good ideas, ones on which time and money have been spent in assessing their potential as profit producers, have failed to get into development schedules as a result of neglect and oversight. Positioning these in a special category reduces this risk.

Scheduled Phase: In the analysis of a product portfolio, projects awaiting development are a sign of management vigor in promoting new product programs. When too many projects are awaiting development, this fact may point up organizational weaknesses such as inadequate development appropriations or staffing.

Developmental Phase: This is the phase in which ideas are turned into commercially feasible products. Everything that must be done to produce a saleable product takes place here. Known facts are applied in developing the new product. Research is undertaken to supply new understanding to enhance product development. These facts and this understanding should encompass both the physical sciences as well as economics and fundamental knowledge of customer motivation if a complete job is to be performed.

Ideas and information are the raw materials in the development process. Saleable merchandise is the end product of effectively applied technical talent. In between these two, the success of the business is largely determined. Second or third-rate talent here will be reflected in competitive weaknesses of final products. Products leaving the developmental phase should be ready for sale in every respect and, until ready, should remain under development.

Planning for Tomorrow

Positioning individual products properly with respect to their own place in the life-cycle will do more to reveal to engineers new needs than any other step that can be taken in evaluating the soundness of product programs.

In this age of steadily advancing technologies, top-management is becoming increasingly aware of the rapidly growing need for dynamic product-portfolio management. Product-portfolio analysis is the starting point in planning for profits. The insight revealed by such analysis joined to that gained by perusing financial statements provides the perspective that turns words and numbers into meaningful facts and figures. It can be a potent tool both in positioning the present and projecting the future.

Tips and Techniques

Squaring Numbers Ending in 0.5

A method of squaring numbers ending in 0.5 makes use of simple subtraction, mathematical tables of squares, and simple addition. To square a number ending in 0.5, subtract 0.5 from the number to make it a whole number. Then add this whole number to its square, which is easily obtained from tables. Finally, add 0.25 to this answer to obtain the exact square of the original number.

For example, find the square of 533.5. Subtract 0.5 from 533.5 to obtain 533. Look up the square of 533, which is 284089. Add 533 to this square to obtain 284622. Then, add 0.25 to this number to obtain the exact square, 284622.25.—Hursh Parikh, *engineer, Hengelo, Holland.*

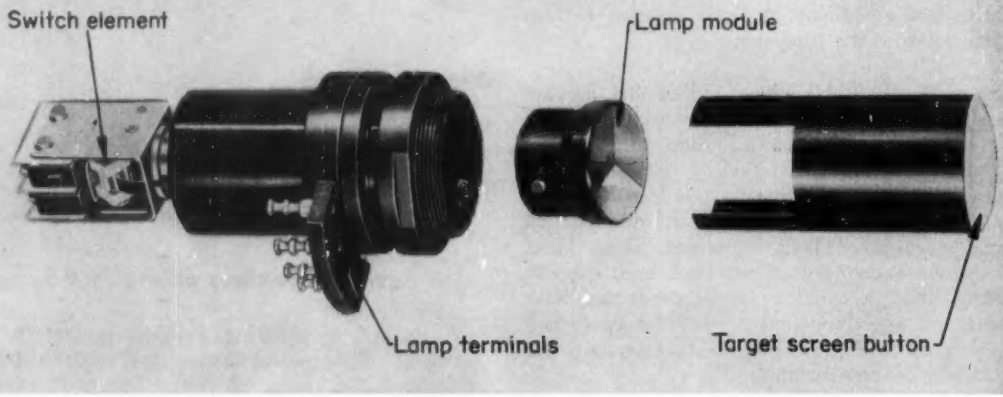
Estimating Aluminum Bar Weight

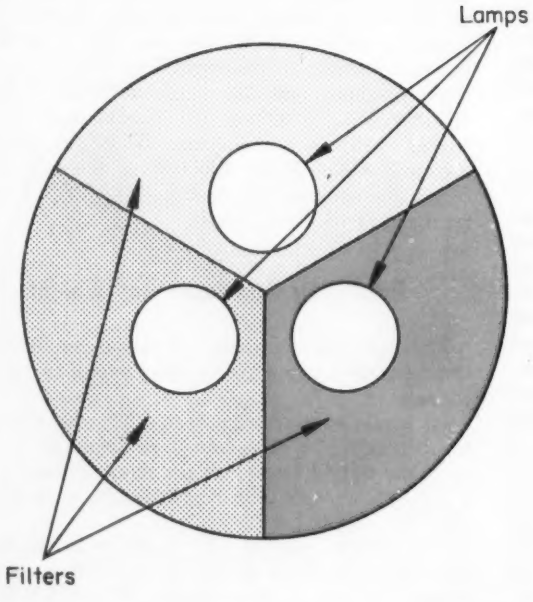
The approximate weight of aluminum bar stock can be readily estimated by using one of two simple formulas.

For squares or rectangles, multiply the width by the height, add a zero, and then divide by 9. This gives the weight in pounds per foot. Example: Bar size 6 by 2 in: $6 \times 2 = 12$; add a zero to make 120; $120/9 = 13\frac{1}{3}$ lb per ft.

For rounds, multiply the diameter by 4, square the result, and divide by 18. Example: Bar size 2-in. diam: $2 \times 4 = 8$; $8^2 = 64$; $64/18 = 3\ 5/9$ lb per ft.—J. B. Deakin, *Essex, England.*

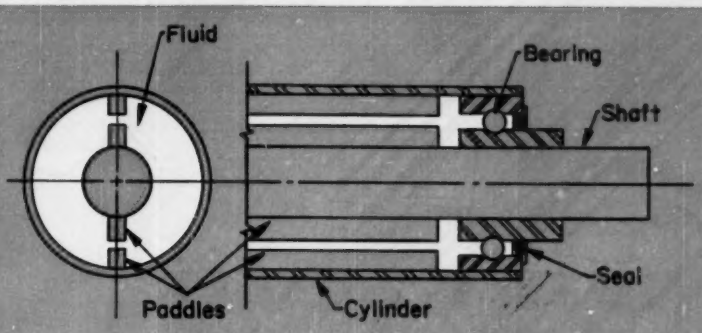
scanning the field for *ideas*



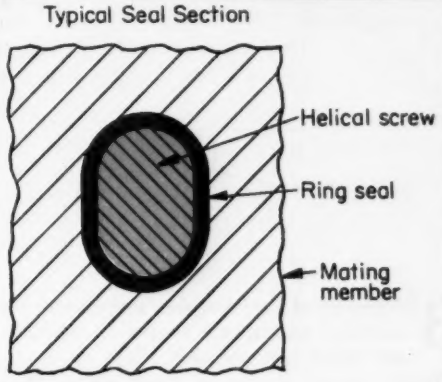


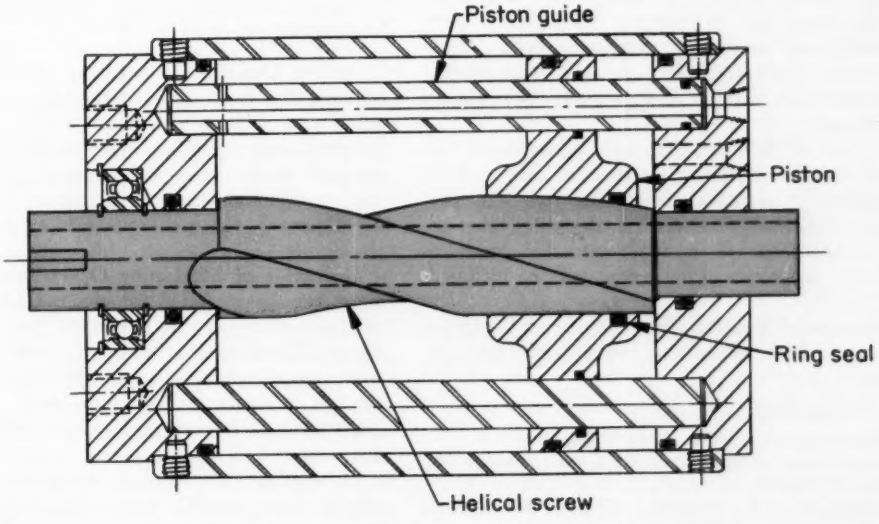
Three-in-one color element indentifies active circuits by monitoring three different conditions of a pushbutton, one at a time. In the Trilite, a filter at the top of the lamp module has three equally spaced color areas with a lamp in each. The illumination of each individual lamp passes through a color segment of the filter and is projected evenly on the button target screen. Each push of button changes circuit and lights different lamp to give different color signal.

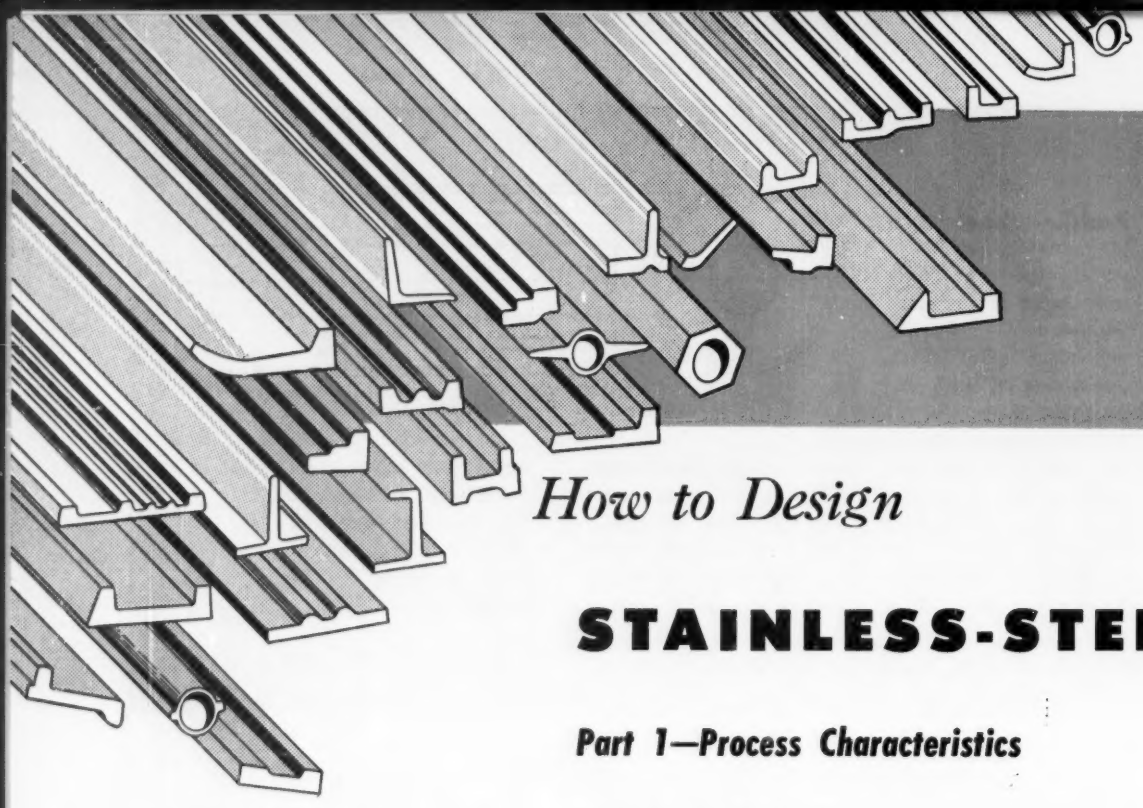
Paddle-wheel drive for rotating cylinders permits operation under unbalanced torque loads without damage. A cylinder, which is fluid filled, carries paddle blades running the length of its interior surface. Matching paddle blades are mounted on the surface of the drive shaft which passes through the center of the cylinder. Roller bearings at the ends of the cylinder permit relative motion of the shaft and cylinder. In operation, the assembly acts as a fluid clutch to permit slippage under torque unbalance. As employed by Harry J. Ferguson Co., the design permits a roller in a continuous-drive conveyor to be stopped without damage.



Twisted-rod screw design converts linear travel of hydraulic piston to rotary motion and simplifies sealing problems. In a rotary actuator by Carter Controls Inc., a piston with a broached center opening serves as the nut in a power screw assembly. The helical thread of the screw has a cross section in the form of a circular rod with opposing flat surfaces. A formed rubber ring on the broached surface of the piston opening seals the nut-screw assembly. In operation, the piston is constrained to move in a straight line by rod guides, imparting rotary motion to the screw member.







How to Design

STAINLESS-STEEL

Part 1—Process Characteristics

By RICHARD E. PARET
Stainless Steel Specialist
American Iron & Steel Institute
New York, N. Y.

BENEFITS of the extrusion process can now be extended to intricate shapes in stainless steel and other high-strength alloys.

While special shapes in these alloys are often desirable from an engineering standpoint, their availability was previously restricted. Today, complex shapes which are hollow or solid, symmetrical or asymmetrical, can be designed and extruded in stainless steel.

Part one of this two-part series introduces the designer to the extrusion process in terms of its applicability to stainless steel. Part two will present recommended practices for designing the extrusion. Features of multiple-extrusion practices and design potentials of extrusions will be included.

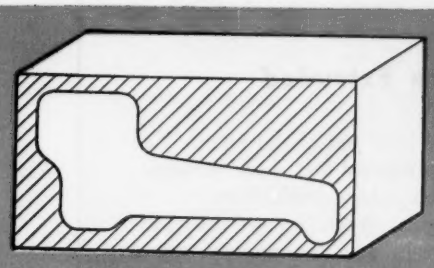
Advantages of Stainless-Steel Extrusions: Designers can expect these advantages when specifying extrusions:

1. Great freedom of section design.
2. Reduction or elimination of machining operations.
3. Production of integral complex shapes which would normally require joining two or more components.
4. Economical small production runs when demand does not justify rolling.
5. Production of shapes impossible to roll or not offered in the grade of stainless steel desired.
6. Availability of the shape when required.
7. Economies over comparable cast or forged parts.
8. Improved mechanical properties of parts subjected to transverse loading.

Section Design: An increased section modulus is possible for a specific weight-per-foot of steel for solid and hollow extruded shapes. This design freedom means mechanically strong components at reduced weight. Generally speaking, the weight of the average stainless-steel extrusion is approximately 3.4 lb per ft for each square inch of cross-section.

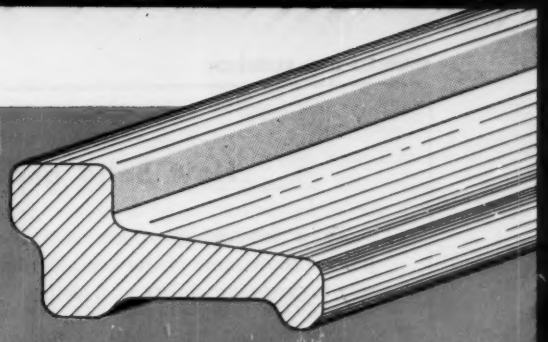
Reduction of Machining Operations: Existing designs can be modified for the extrusion process to produce, or closely approximate, the final required shape. Thus, savings through increased yield and reduction of machining and material handling costs can be considerable. Similar parts, produced by extrusion and by conventional machining practices, are compared in Fig. 1.

Generally, finishes and tolerances attained by extrusion are roughly comparable to those produced by conventional hot-rolling methods. Where volume



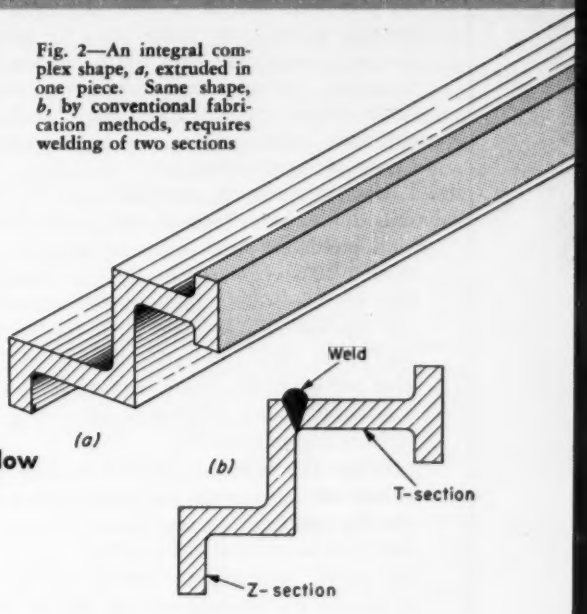
Part machined from stock

Fig. 1 — Aircraft part of stainless steel having a cross-sectional area of 1.35 sq in. Production of the part by conventional machining methods requires stock of 2.63 sq in. in cross-sectional area. Resultant waste from stock removal is 1.28 sq in. The same shape can be extruded finished with no waste involved



Finished part extruded

Fig. 2—An integral complex shape, *a*, extruded in one piece. Same shape, *b*, by conventional fabrication methods, requires welding of two sections



EXTRUSIONS

- **Advantages of the extrusion process**
- **Properties of stainless-steel extrusions**
- **Production of intricate shapes—solid and hollow**
- **Limitations of extrusion**

production warrants, extruded parts can be cold drawn to improve surface finish and to decrease tolerances to closer limits. Uniformity of sections is also assured by cold drawing to produce dependable surfaces for subsequent machining.

Integral Complex Shapes: The stainless-steel part, Fig. 2*a*, shows the intricacy of section designs which can be produced without welding. Normally, this part would probably be produced by welding together Z and T-sections, Fig. 2*b*.

When necessary, extruded shapes can be designed to include relatively thin flanged edges for mounting purposes. This modification permits use of certain automatic welding methods for assembly.

Production Costs: Design and construction costs of extrusion tools are extremely low—in the $150 to $175 range. By contrast, special rolls to produce nonstandard sections may cost from $1000 to $10,000, depending on the job. When small quantities are required, production of these shapes by extrusion offers outstanding economies. Extrusion, however, does not compete with the rolling process

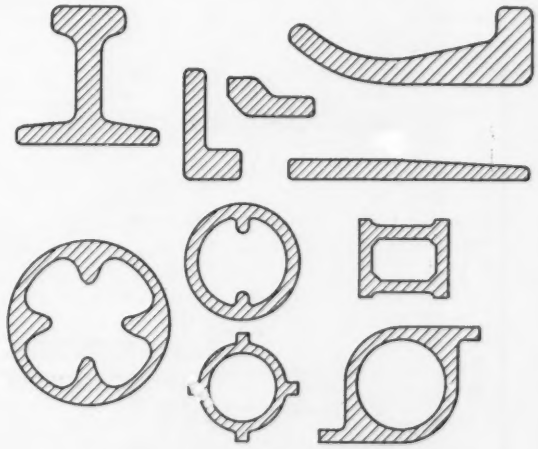


Fig. 3—Extruded hollow and solid sections which may be impossible to roll. Internal configurations of the hollow shapes are obtained by extruding over a shaped mandrel. For many applications, special shapes are extruded in stainless alloys which are unavailable as seamless tubing

How Solid and Hollow Shapes Are Extruded

These interesting aspects of the extrusion process show some of the considerations necessary to produce stainless-steel shapes.

Solid Shapes: The billet to be extruded is cut from a hot-rolled round, conditioned to remove surface imperfections, and chamfered on the front end. It is then preheated and brought to extrusion temperature by submersion in a molten-salt bath which restricts scale formation, carburization, decarburization, or other surface reactions. Rapid corner cooling of the billet during transporting is prevented by the front-end chamfer.

Upon reaching the extrusion press, the billet rolls down an inclined charging table covered with powdered glass and into the press container. Tooling arrangement is shown in Fig. *A*. Container lubrication is provided by the thin veil of glass fused to the periphery of the billet. Die lubrication is applied by a glass pad which provides a reservoir from which a uniform coating of glass is fed over tooling surfaces during extrusion.

Before the extrusion cycle, a dummy block is inserted between the ram and billet to protect the ram from damage due to pressure and heat and to prevent backward extrusion of the hot metal. Action of the ram causes the steel to assume the configuration of the die orifice through which it is forced. On completion of the stroke, a high-speed saw separates the extrusion from the butt end of the billet. The ram again moves forward and ejects the extrusion from the press at high speed.

Extruded lengths, depending on the grade of stainless steel, are immediately water quenched or allowed to cool in air before transfer to stretcher-detwisting equipment. Here, twists and bends which result from metal flow and cooling are removed.

When uniform and straight, extruded bars are cut to length and, when required, scale and glass deposits are removed from surfaces by shot blasting, Wheelabrating, or by chemical conditioning. Extruded shapes can then be cold drawn or subjected to thermal treatment.

Hollow Shapes: The procedure for extruding hollow shapes usually begins with piercing the billet in, for example, a vertical piercing press, Fig. *B*. The pierced hole should allow a minimum $\frac{1}{8}$-in. clearance around the mandrel for lubrication. The billet is then reheated and placed in a double-action press. The mandrel moves forward into the pierced hole and is positioned to project past the forming edges of the die. The inner contour of the shape is established by the mandrel's configuration. The hot billet is then forced to flow between the mandrel and die to form the hollow section. The mandrel is activated independently of the ram while entering and with the ram during extrusion.

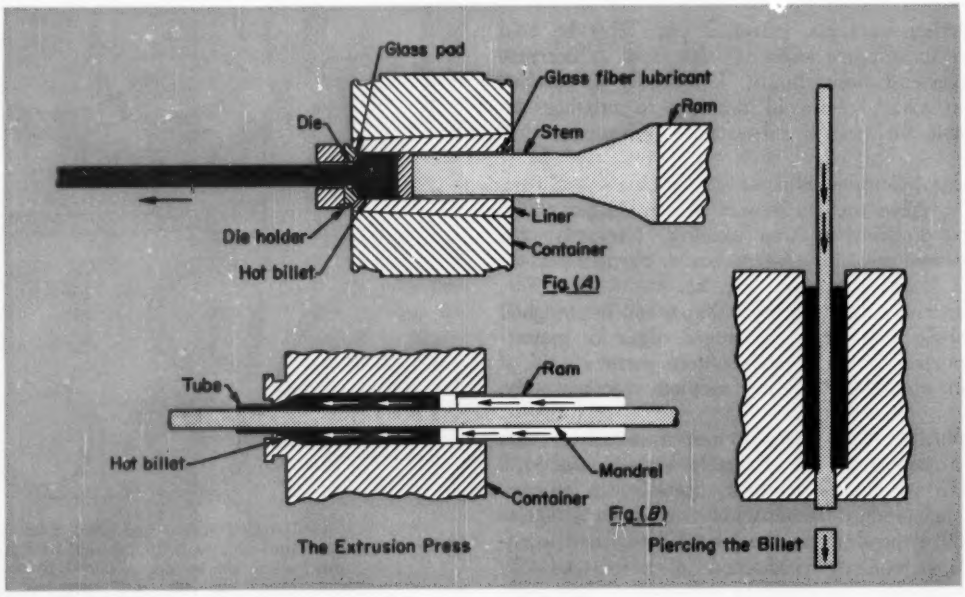


Fig. 4—Cross section of an extruded locker handle. The shape, extruded in a continuous length, is simply "sliced" to size prior to use. Only light finishing and polishing are required with such parts. Comparable cast parts require additional machining and finishing operations

Table 1—Properties of Extruded Stainless-Steel Bars

Stainless Type	Condition of Bar	Direction of Stress	Yield Strength, 0.2% offset (psi)	Ultimate Strength (psi)	Elongation (per cent)
304	As extruded	Longitudinal	30,600	80,700	57
		Transverse	30,500	80,700	60
310	As extruded	Longitudinal	31,100	76,000	54
		Transverse	32,000	75,300	57
316	As extruded	Longitudinal	32,400	75,200	68
		Transverse	31,700	75,900	68
321	As extruded	Londitudinal	31,000	82,200	63
		Transverse	32,000	81,000	69
410	As extruded	Longitudinal	83,300	101,000	25
		Transverse	84,100	101,600	23
410	Heat treated: Oil quenched from 1750 F, and air cooled from 1000 F	Longitudinal	132,600	150,500	20
		Transverse	134,500	158,200	20

for production of standard sections or large quantities of stainless-steel sections because of higher overhead which is reflected in the per-pound price of extruded shapes.

Another important consideration is the extreme flexibility permitted by low extrusion tooling costs. Since today's designs are subject to frequent changes, the advantage of changing tooling "in midstream" at little cost is obvious.

Extruding "Impossible" Shapes: Hollow or solid sections, so complex that rolling them is impossible, can be produced economically by extrusion. The versatility of the process is demonstrated by the variety of shapes produced, Fig. 3.

Shapes which are not offered in the grade of stainless steel desired are now obtainable. For example, alloys such as Type 440C, considered unpierceable and therefore formerly unavailable as seamless tubing, are readily extruded.

Availability of Shapes: Frequently, 1000 lb or less of a shape may be needed with product demand recurrent over a long period of time. Since extrusion dies are easily changed, these requirements can be fulfilled economically.

The great adaptability of the extrusion process also provides the additional advantage of stepping-up delivery schedules. The average present time-span between placement of a large order for a complex extruded shape and delivery is approximately four to six weeks. This includes die design consultation, die making, experimental production cycles, heat treatment of parts, straightening, cleaning, and final inspection.

Comparison with Castings or Forgings: Finishing operations can be materially reduced when extrusions are specified for conventionally cast or forged shapes. In addition, many finished parts can be extruded over continuous lengths and simply sliced to size, Fig. 4.

Mechanical properties of extruded parts are superior to those of cast parts and roughly comparable to those of forged parts. This is mainly a result of the thorough working of the metal during extrusion, which produces excellent grain refinement and compaction. Metal flow is good since extrusions are kept under compression during deformation. Thus, problems encountered with many alloys during hammer work, from superficial cracks to complete rupture of the material, are avoided.

Where quantities permit, extrusions can sometimes be used as blanks to simplify subsequent forging procedures. Frequently, fullering or blocking breakdown operations, which might normally be required with circular or rectangular forging stock, may be entirely eliminated by this method.

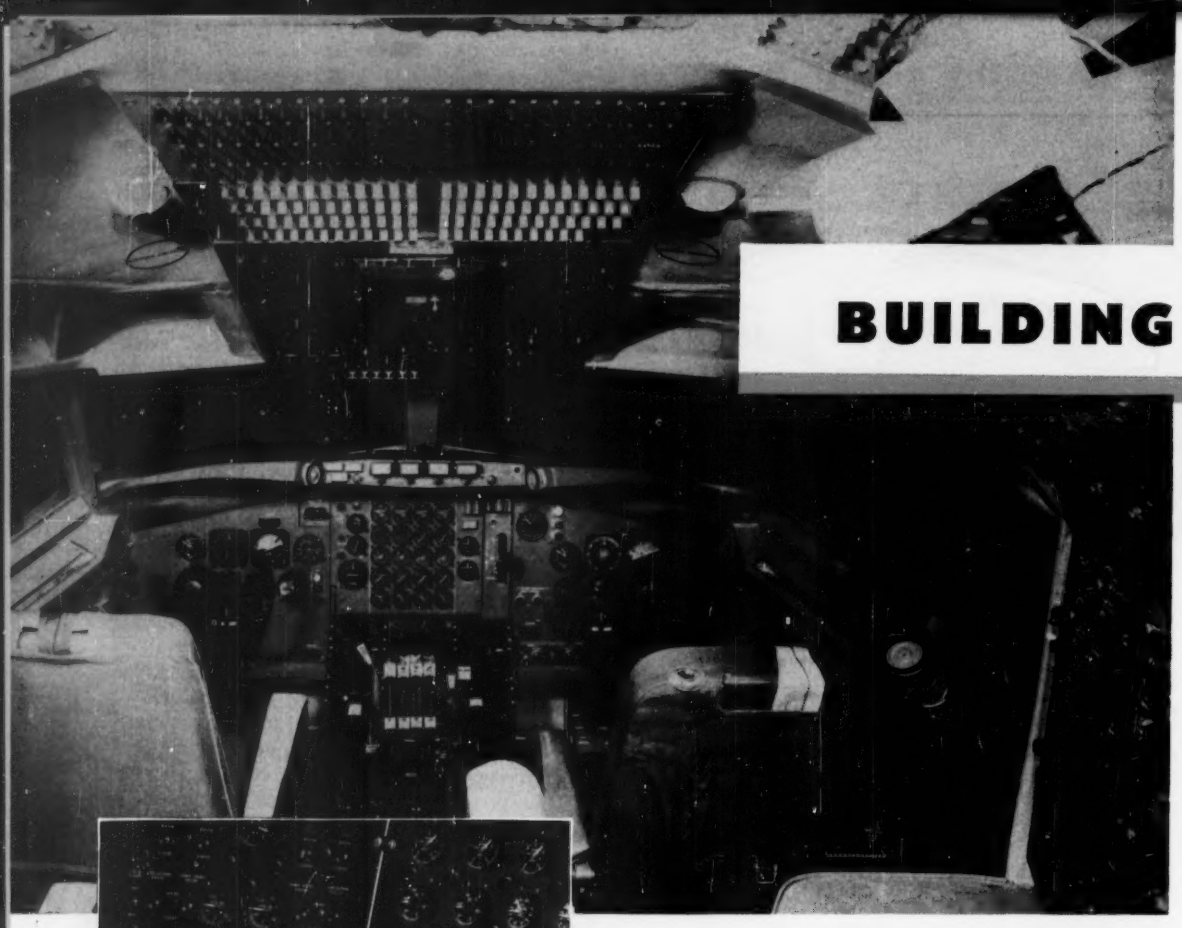
Mechanical Properties: Data on properties of extruded stainless-steel bars are shown in Table 1. The relatively equal values for transverse and longitudinal mechanical properties should be noted. This isotropy is extremely valuable for parts subject to transverse loading in service, especially where tensile stresses are involved.

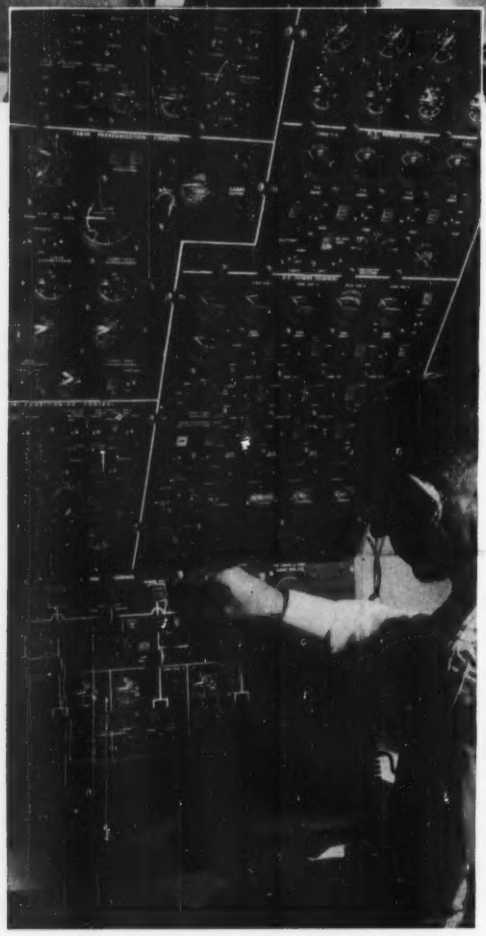
Applications and Limitations of Extrusion: Developments in the industries of refining, chemical processing, aircraft, and atomic energy have created an increased need for special stainless-steel tubular and hollow components. For many of these applications, special tubes with dissimilar inside and outside contours are easily extruded in long lengths. Parts shown in Fig. 3 indicate possible shape variations. Also, other hollow shapes, impossible or impractical to fabricate, may be made commercially available as extruded products.

As with all methods of fabrication, the extrusion process poses particular design problems. The maximum circumscribing diameter of parts, for example, is limited by equipment available to furnish the severe pressures required. Lubricant control and die design are still problems, and dies must be replaced frequently to maintain good tolerances Hardened tool-steel dies will generally provide approximately 1000 ft of extruded stainless steel. Also, experimentation is constantly underway to increase tolerance control and yield between die changes.

Concluding article in this series will appear in the January 22 issue of MACHINE DESIGN, and shows where and how a stainless-steel extrusion can be designed into a product.

BUILDING





COMMON to all types of instrument design is the necessity for the operator to see the controls and indicators accurately and quickly. Fast, precise seeing requires good instrument lighting, whether the lighting is built in or whether ambient light alone is used. In many machines and equipment where instruments are an integral part of their design, ambient lighting varies over a range from bright sunlight to complete darkness. Prime examples of these extreme lighting conditions are encountered in passenger cars, trucks, and aircraft, Fig. 1.

In aircraft, the necessity of protecting night vision is well known. Not so well known is the psychological tendency for the illuminated instrument markings to appear to float in space. A pilot staring at a lighted panel on a dark night experiences the sensation of the markings becoming detached from the instrument. The effect is obviously discon-

Fig. 1—Cockpit of the new Boeing 707 Stratoliner, above, and flight engineer's station in new Convair 880 jet transport, left. Controls and indicators in these aircraft must be designed for optimum readability under all possible seeing conditions—daylight, twilight, night, and instrument flight

By V. A. ORLANDO and J. J. FRAIZER
Instrument Dept.
General Electric Co., West Lynn, Mass.

LIGHT INTO INSTRUMENTS

. . . for daylight and night vision

- Built-In Lights
- Lighting-Assembly Parts
- Light Balancing
- Design for Heat

certing, but so common that it is considered normal. Supplying background lighting to the dark portions of the instrument will relieve this effect.

In addition to these requirements, lighting must provide adequate contrast between the markings and background, whether the instruments are illuminated with electric lights or daylight. When illuminated with electric lights, the color of the markings should protect night vision; this is a must in aircraft instruments. For proper contrast in daylight, markings should be white in most applications.

Lighting hardware must not interfere with instrument visibility. The accuracy and performance of the instrument should not be affected, and the additional weight, size, and cost of lighting must be minimized.

Built-In Lights

Because of the disadvantages of lighting by sources external to the instrument, the present trend is to build the illumination into the instrument. In a built-in lighting system for instruments, all external fixtures are eliminated. Clarity of the markings and uniformity of the lighting can be excellent. Stray light is almost eliminated. The problems of night vision and psychological floating of dial markings are overcome and the general appearance of lighting can be highly attractive.

A typical, well-designed instrument and its optical parts are shown in Fig. 2. Three miniature incandescent lamps illuminate the dial. The light diffuser plate fitting over these lamps distributes light from the three point sources so that the clear-plastic pointer and scale are uniformly lighted.

Lighting-Assembly Parts

The important lighting parts of a transilluminated instrument are lamps, lamp sockets, metal front plates, scale plates, diffuser plates, pointers, etc. Each must be considered in a successful design.

Lamps: In general, lamps are not energized at all times an instrument is operated. When the lamps are on, they will normally be energized considerably below rated voltage. For these reasons, many lamps can be selected which will last the life of the instrument even when sealed inside the case, provided proper care is exercised in the design to remove heat from the area of the lamp. More than one lamp is usually built in so the instrument will remain readable even if one lamp does burn out. In many instruments, even with one lamp out, the lighting is adequate.

Lamp Sockets: Usually made of aluminum, lamp sockets are designed to conduct current to the lamp and to remove as much heat as possible. The socket in Fig. 2 is staked to the front plate to increase thermal conduction to the case.

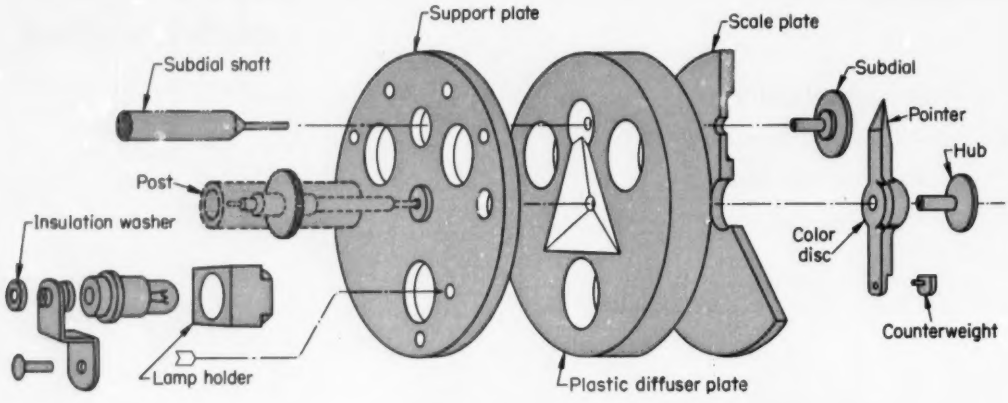
Metal Front Plates: It is important that the

front plate should be of sufficient area to completely support the diffuser plate, if the diffuser plate is made of plastic, since high temperatures will otherwise cause it to sag.

Scale Plates: Three design functions accomplished by scale plates are:

1. To carry the scale markings.
2. To place the filter where required to obtain the proper color of illumination.
3. To control light balance and brightness.

The chromaticity of the plastic in Fig. 2 is well into the red so that night vision is not destroyed but not so deep that it becomes impossible to obtain adequate brightness. Light rays passing through the



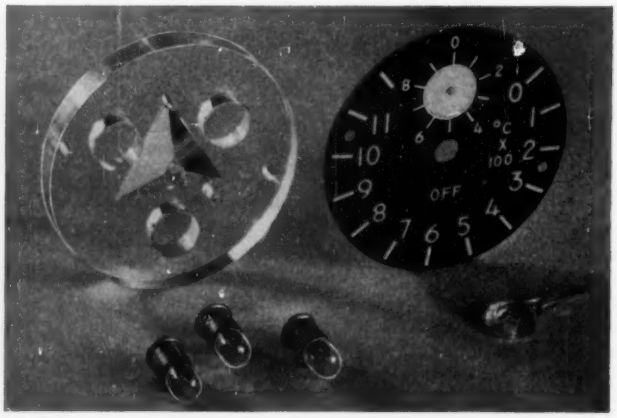
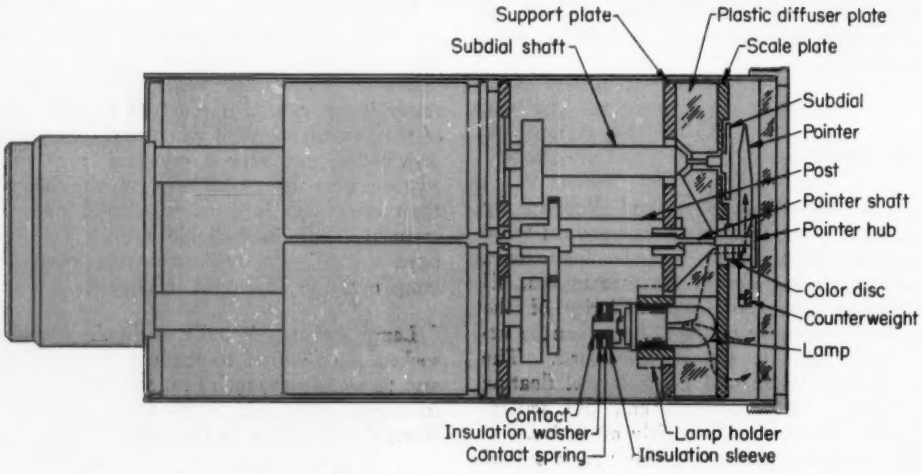


Fig. 2—Instrument with built-in lamps for lighting dial and pointer. Clear-plastic diffuser plate distributes light uniformly. Dial is printed on red plastic. Markings are translucent white. Translucent black background provides backlighting to prevent visual floating effect. Light path through plastic parts is shown by dotted lines, below



scale plate from back to front transilluminate the markings so that they appear red.

To maintain the instrument volume as small as possible, the lamps should be placed almost in contact with the back of the scale plate, Fig. 2. In small-diameter instruments, they are directly behind the translucent markings. This causes the scale plate area immediately above the lamp to appear very intense, but this intensity reduces rapidly at points remote from the lamps. To illuminate the dial uniformly and maintain the brightness within required limits, a combination of light diffusion, opaquing, and conduction must be employed.

Diffuser Plates: In lighted instruments, diffuser plates should be used for the following reasons:

1. To conduct light to the pointer to obtain sufficient pointer brightness.
2. To aid in lighting the scale plate uniformly.
3. As a spacer so that light can be transmitted with minimum obstruction between scale plate and metal top plate of the instrument.
4. To thermally insulate the scale plate in some applications.

Diffuser plates can be made of clear plastic or glass with about the same diameter as the scale plates. They are usually $\frac{1}{8}$ to $\frac{1}{4}$ in. thick. Reflecting surfaces are molded into the center to reflect light from the lamp to the pointer, Fig. 2. Holes are provided in which lamps are located. To insure proper pointer brightness, the filament should be positioned within the diffuser plate although its exact position is not critical. Thickness of the diffuser plate is largely determined by the filament location; the greater the tolerance on the filament location, the thicker the plate. A thin diffuser plate—$\frac{1}{8}$ in. thick—can be used with thicker bosses surrounding the lamps.

Partial reflection and transmittance of light by the diffuser plate tends to light the scale plate more uniformly.

The use of blind lamp holes, Fig. 3, which can be obtained with glass diffuser plates tends to thermally insulate the scale plate. This is important in high-temperature applications because the scale plate often imposes the upper-temperature operating limit on the lighted instrument. Molding techniques for plastic diffuser plates do not economically allow blind lamp holes.

Pointers: Lighted pointers should be designed to meet the following requirements:

1. Obtain uniform brightness.
2. Obtain sufficient level of brightness.
3. Make the length and width of the pointer functional and attractive.
4. Keep the pointer thickness small to improve appearance and minimize weight.
5. Maintain the tip of the pointer close to the dial to minimize parallax.
6. Prevent light from leaking around the hub of the pointer when viewed from an angle.
7. Construct the hub so the pointer can be removed and replaced on the shaft.

By total internal reflection, light is reflected from the lamps through the diffuser plate into the pointer in the design in Fig. 2. Light enters the pointer through a red filter. The diameter of the filter is smaller than the hub of the pointer, and an effective light trap is formed in conjunction with the scale plate to prevent light leakage around the hub, Fig. 4.

A reflecting surface in the pointer transmits light to the tip, Fig. 4. This surface is of about the same diameter as the red filter and is inclined as much as possible without breaking through the thickness of the hub. The angle ϕ is usually much less than the theoretical optimum of 45 deg. If the area of this inclined surface is as large in diameter as practical and it is coated with a diffused white, approximately optimum brightness is obtained. For pointer lighting, diffused reflection has been found more effective than reflecting light from polished surfaces.

Light Balancing

To light-balance a scale plate uniformly, a heavy uniform coat of white paint is applied to both sides of the scale plate. Then the translucent black background coat is added to reveal the markings. Additional heavy coats of white paint are added immediately over the area of the lamps. The back surface—prism-indentation side—of the diffuser plate is coated white, keeping the reflecting prism surfaces and lamp holes clear.

The white coating immediately over the lamps tends to reduce the concentrated intensity of the

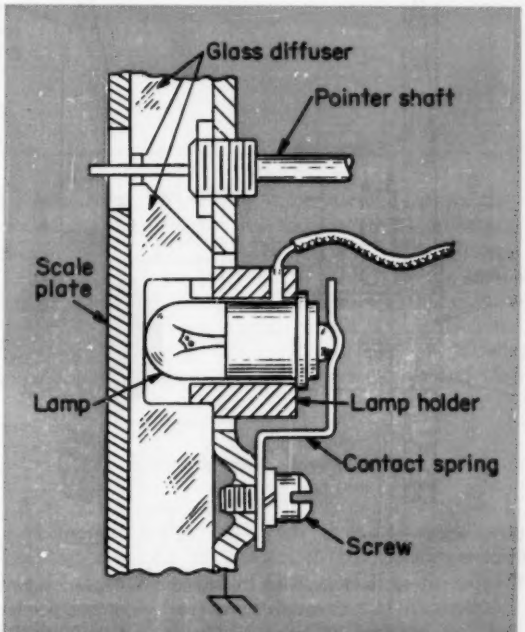


Fig. 3—Method of holding lamp and lamp socket in place if diffuser plate is made of glass

filament and diffuses the light as is passes through the scale plate from the back to the front. As this light strikes the front surface, additional reflections occur. The uniform coat on the back surface of the scale plate continues this reflection and diffusion. The resulting scale plate is approximately uniform but is not completely acceptable. To complete the light balancing, a large amount of light is added to the scale plate by adding white paint to the back of the diffuser plate.

This light added by the diffuser plate is quite uniform since it comes from reflection off a diffused surface relatively far from the scale plate—the bottom of the diffuser plate. As a result of this large amount of uniform light, variation in uniformity of the scale plate is greatly decreased although the scale plate illumination has been greatly increased. To reduce brightness of the scale plate, to the required level, additional uniform coats of white paint are added which tend to increase the effective diffusion of the scale plate. The result is that scale-plate illumination is very uniform.

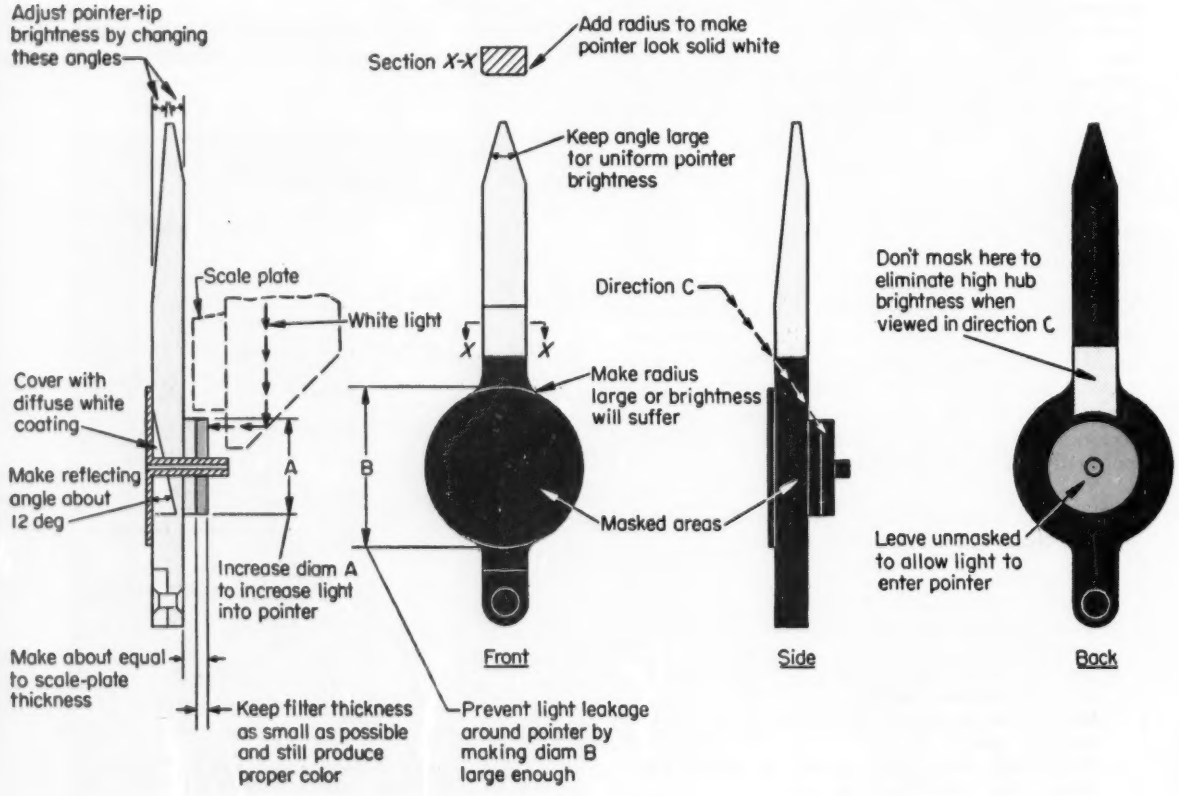
▶ Design for Heat

In general, acrylic resins are the best plastic materials for use as lighting components. Not only do they have the features of being optically clear, lightweight, relatively inexpensive, and workable, but they can be obtained in chromaticities that are very satisfactory for night vision. Also, the acrylics are about the best clear, high-temperature materials available.

Pointers molded of acrylic-resin powders will withstand a total temperature of 100 C, if the structural shape is proper and the part must only support itself. A chunky part such as a molded diffuser plate will operate satisfactorily to about 115 C if properly supported. Pointers machined from cast acrylics have withstood temperatures above 130 C satisfactorily.

Instrument Mechanisms: Three No. 328 lamps operating at 5 v dissipate about 3w of power. An instrument that tends to be marginal without lamps at 70 C ambient may be completely unsuited for

Fig. 4—Design factors which control pointer-brightness uniformity. Gray areas show how to mask pointer to prevent hot spots and light leaks. Masking should have white undercoating


Adjust pointer-tip brightness by changing these angles
Section X-X
Add radius to make pointer look solid white
Keep angle large for uniform pointer brightness
Scale plate
White light
Direction C
Don't mask here to eliminate high hub brightness when viewed in direction C
Cover with diffuse white coating
Make radius large or brightness will suffer
Make reflecting angle about 12 deg
A
B
Masked areas
Leave unmasked to allow light to enter pointer
Increase diam A to increase light into pointer
Front
Side
Back
Make about equal to scale-plate thickness
Keep filter thickness as small as possible and still produce proper color
Prevent light leakage around pointer by making diam B large enough

use with lamps. First, the construction may fail. For example, soldered joints may creep, or low-temperature magnets may suffer permanent loss of flux. Secondly, instrument accuracy may suffer since the temperature compensation must operate over a significantly greater range.

These problems have no general solution but must be handled on an individual design basis. Some of the methods available to the designer to keep critical parts at the lowest temperature possible are to insulate them from the hot spots, for example, by the use of a glass diffuser plate with blind lamp holes, Fig. 3. Another solution is a metal thermal conducting path to the case. Maximum convection cooling can be provided by using large air spaces wherever possible. A helium atmosphere can be used in the instrument.

Lamp Life: High temperatures shorten lamp life by affecting the seal and by driving gases from the glass which contaminate the filament. The ambient temperature of the lamp is considerably above the total average temperature of the inside of the instrument because it is located in the very confining space in the diffuser plate.

Thermal Expansion: When plastic materials become hot, they become extremely soft and some materials discolor. The coefficient of thermal expansion of plastic is much greater than metal which sometimes presents problems. Colored plastic sheets used as filter materials often lose color.

The high coefficient of expansion of plastics can cause many problems. In particular, a scale plate may expand and interfere with the pointer hub since the clearance between these two parts is necessarily small to prevent light leakage. Dishing can also result particularly when paint is applied to only one surface of a plastic part. With proper design these problems can be overcome.

Coatings: Obtaining paints that will withstand the high temperatures is a major problem. Coatings must be carefully tested to see that they do not discolor, blister, peel, or cause the coverglass to fog. Coatings increase the tendency for dye in colored plastics to bleed. The scale plate is particularly subject to these problems because the markings are applied over a red plastic material. The scale plate is located almost in contact with the hot lamps and the scale side of the scale plate is only supported around the edge by a few screws, allowing it to dish or warp in spots. Also, any volatiles from the scale plate immediately condense on the coverglass, causing fogging. For these reasons, the scale plate limits the top temperatures to which lighted instruments can be subjected without damaging them.

Glass vs. Plastic: In general, glass is not affected by even the high temperatures expected in instruments. In many cases, glass parts are less expensive than plastic (diffuser plates), although not always (pointers). Glass can be used to insulate parts adversely affected by heat.

A drawback of glass is that it has been difficult to get the proper chromaticity of glass for use in scale plates. Glass is about twice as heavy as plastic. Also, since glass does not have the tendency to "key" to adjoining surfaces unless painted or cemented, it may move when subjected to vibration. It is good practice to allow extra clearance around mounting screws to take care of the relatively low coefficient of expansion of glass.

Tips and Techniques

Cube Roots

Here is an easy trial method for extracting cube roots, which involves only three trials and gives answers as accurate as conventional methods. For example, find the cube root of 5248.263.

First Step: Take any number, which when cubed has a value less than 5248.263. Try 15. Then $5248.263/15 = 349.884$. If 15 is the cube root of 5248.263, then 349.884 must be the square of 15. Obviously this is not true since the square root of 349.884 is 18.750. It follows then that $15\ (18.750)\ (18.750) = 5248.263$.

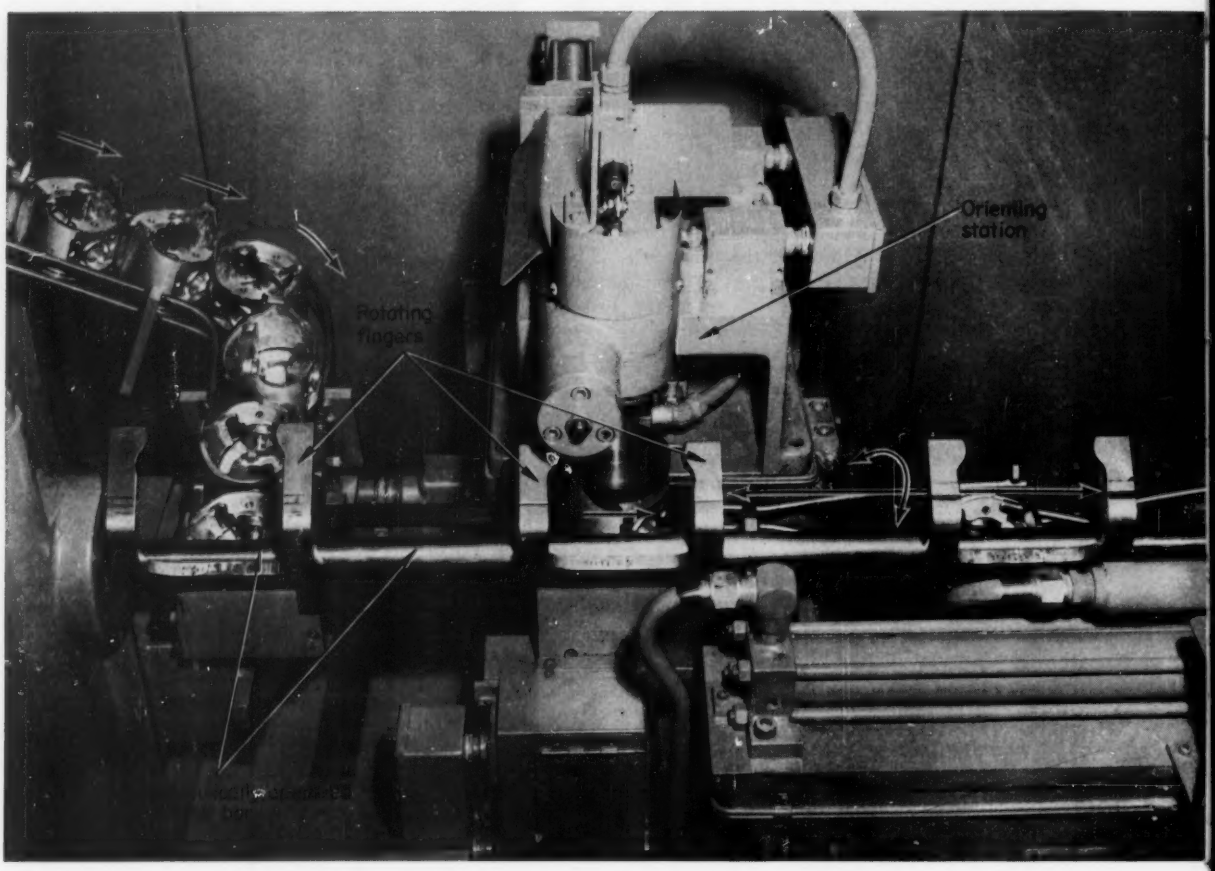
Second Step: A second trial number is obtained from the calculation; $(15 + 18.750 + 18.750)/3 = 17.500$. Dividing the original number by this trial number, $5248.263/17.500 = 299.901$. Again, if 17.500 is the cube root of 5248.263, then 299.901 must be the square of 17.500. The square root of 299.901 is 17.317, so 17.500 is closer, but still is not the root.

Third Step: Using the same method as in the second step, calculate the root or third number: $(17.500 + 17.317 + 17.317)/3 = 17.378$. Hence, $5248.263/17.378 = 302.006$. If 17.378 is the cube root of 5248.263, then 302.006 must be the square of 17.378. The square root of 302.006 is 17.378. Therefore, 17.378 is the cube root of 5248.263.—WARD HARLOW, *mechanical engineer, Cleveland, O.*

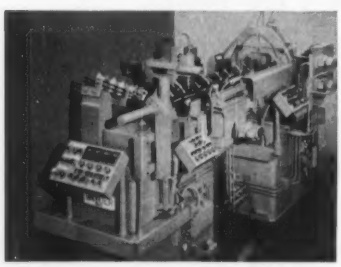
Uniform Line Weights

A thickness gage can be used to standardize and maintain the weight of inked lines on drawings. Establish a set of thicknesses to be used for each type of line. Then when it is necessary to adjust the ruling pen from one line weight to another, the appropriate thickness gage is inserted in the pen and the pen is adjusted. This eliminates the usual trial-and-error method of setting.—HAROLD SEDLIK, *Manchester, Conn.*

"Broken" Tracks in Turnover Device



AUTOMATIC WEIGHING AND MILLING of pistons to precision weight specifications is accomplished with a new in-line transfer machine. Developed by the Snyder Tool & Engineering Co., Detroit, Mich., the machine mills pistons to weight tolerances of ±2 grams at the rate of 600 per hour. Hydraulic power is used for operating clamping, milling-head, and transfer-bar mechanism.

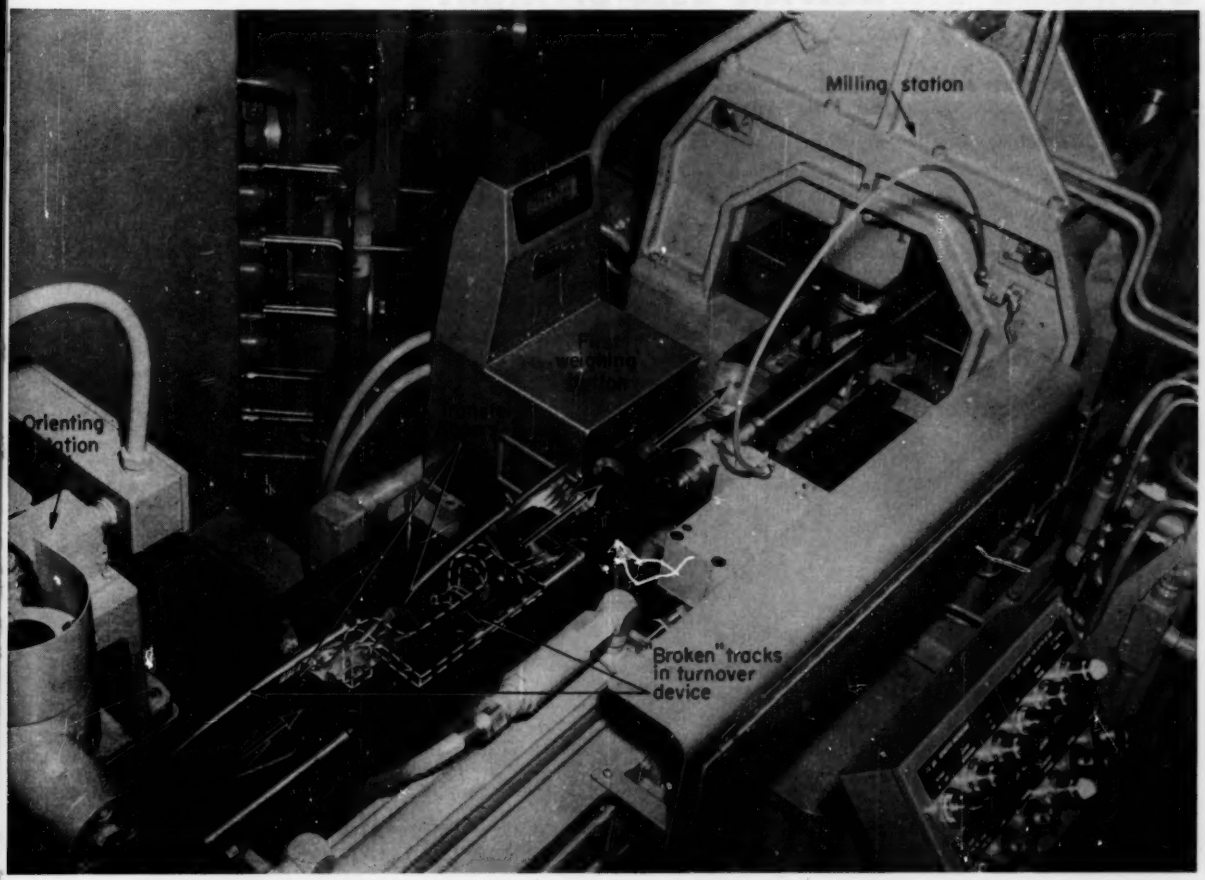


GRAVITY CONVEYOR feeds pistons up-side-down into the loading station of the machine. At the loading station, a rotating-finger transfer mechanism traps the parts one at a time and transfers them to an orienting station. Here the part is sensed for a wristpin offset condition, and repositioned so that all parts enter the next station in identical oriented position.

Parts are transferred to an automatic weighing station. Between the orienting and weighing stations, the pistons are tipped over right side up by spiral transfer rails while they are advanced by the transfer-bar fingers. Overweight is automatically sent by an electronic memory system to the succeeding milling station. The overweight is translated into a wedge stop position for the milling cutter.

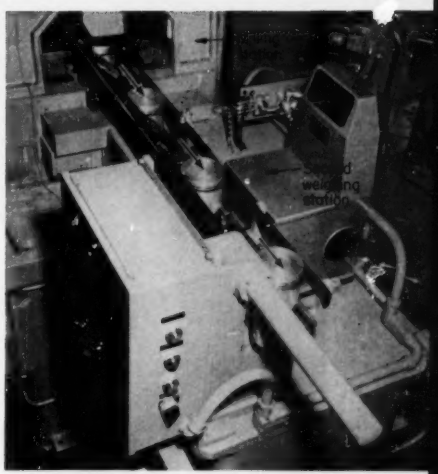
At the milling station, the parts are clamped and milled from underneath by a 3¼ in. diam, inserted-

Provide Opening for Transfer Fingers



blade, carbide milling cutter. After they are milled, the pistons are moved through an in-process gaging station where they are weighed a second time to check the accuracy of the milling operation. Any parts that are outside the weight specifications cause immediate shutdown of the machine.

WEIGHT-REMOVAL POSITIONER precisely locates the wedge stop that determines the depth of cut of the milling cutter. This positioner consists of a servomotor that drives a blocked-center, four-way valve spool. The position of the spool is measured by a differential transformer. When the control circuit operates the valve, the servomotor drives the valve spool until the signal indicating the position of the spool equals the difference between the overweight signal from the memory and the depth-of-cut signal from the wedge stop. The spool then ports the oil to drive the wedge-stop cylinder to reduce that difference to zero. When this occurs, the valve spool will be in the zero position. The zero position of the valve spool will block the ports of the cylinder which actuates the wedge stop and thereby locks it.

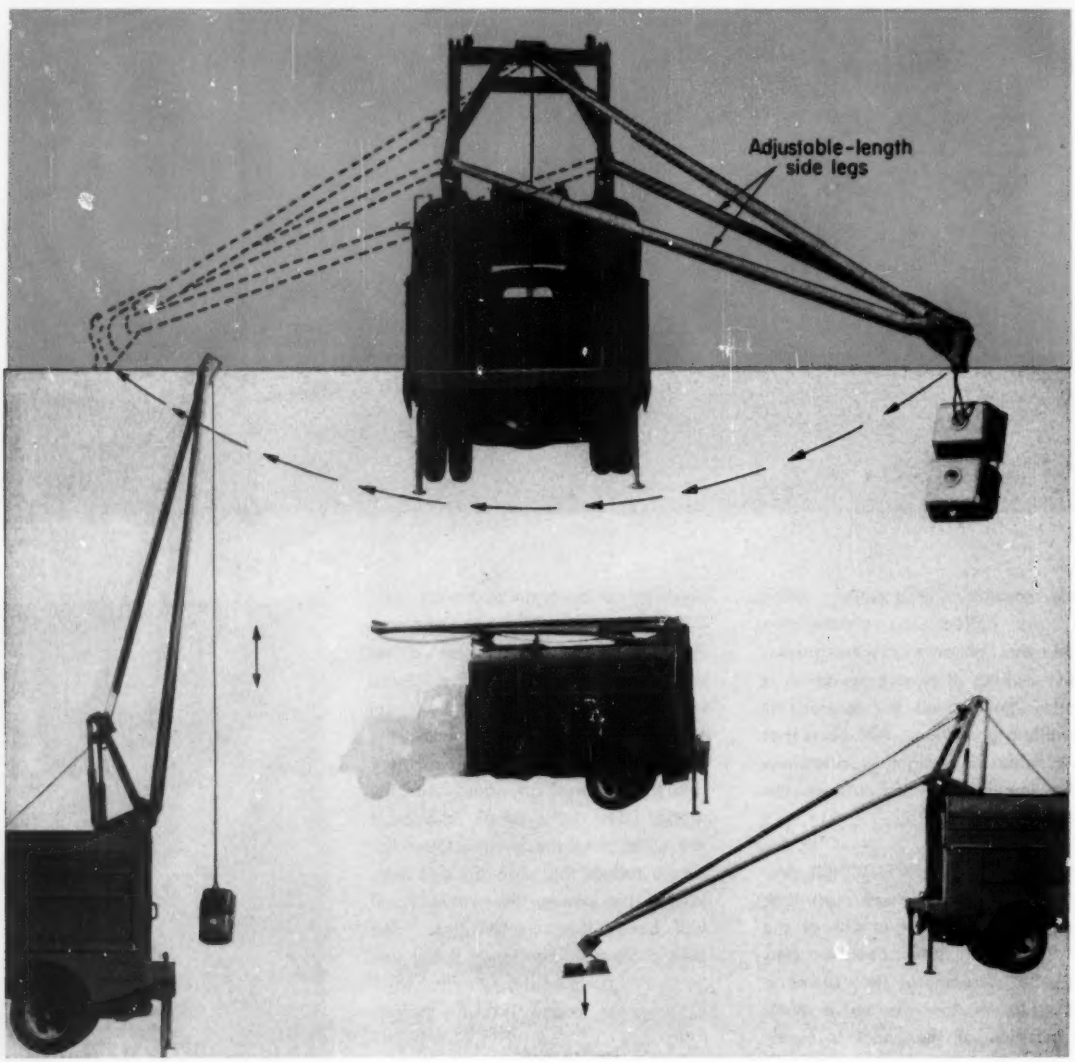


Hydraulic Cylinders Swing Derrick Left or Right

LIFTING AND PUSHING ACTION are produced by a new pole derrick which can reach 9 ft to either side of the truck-chassis centerline. Side, fore and aft, and up and down movement of derrick make it possible to plumb any pole without the use of a pike. Built by the Utility Body Co., Oakland, Calif., the unit has a lifting capacity of 2500 lb with the sheave at ground level and 12,500 lb at maximum elevation. It will handle side-reach position loads up to 3500 lb and apply 3000 to 4500 lb down pressure on a derrick-supported digger.

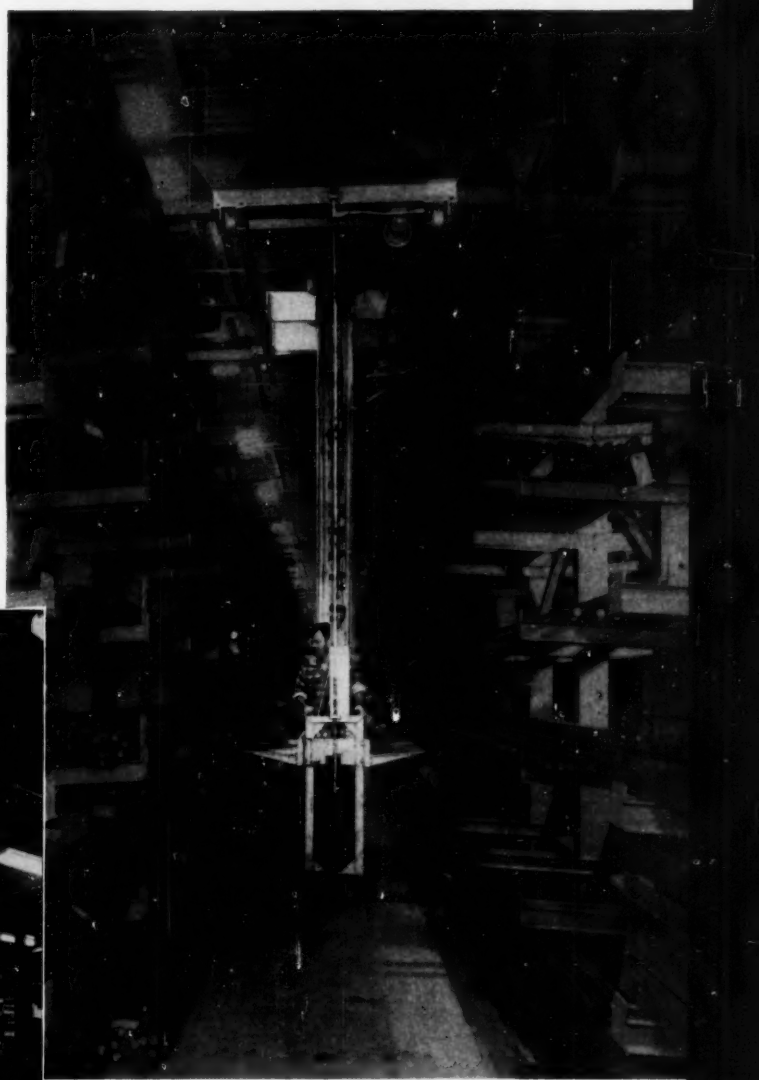
Mounting platform is elevated by simple boost rams. Control valve operating these boost cylinders automatically controls main cylinder. Each side-leg cylinder is operated by a separate valve; these cylinders are an integral part of each leg.

The design allows line trucks to park parallel to curb, reducing obstruction of busy streets. The adjustable side legs simplify the digging of anchor holes with minimum of truck maneuvering. Extensions can be added to side legs to make derrick higher.



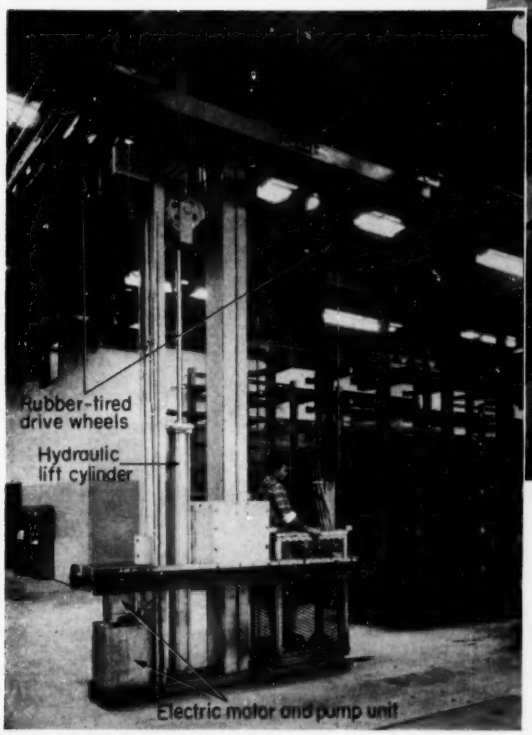
"Lift Truck" on Overhead Crane Moves Sidewise, Up and Down, Forward and Backward

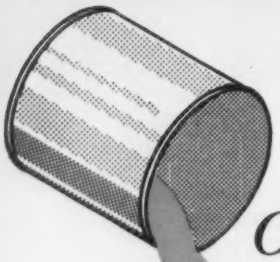
STACKER CRANE hanging on an overhead crane serves as both a lift truck and a traveling hoist for handling bar and rod stock. Installed in the Allen Mfg. Co., Bloomfield, Conn., and designed and built by Walter Kidde Constructors Inc., the one-man-operated stacker crane rides forward, backwards, and sidewise at 125 fpm. It moves up and down at 20 fpm.



ELECTRIC DRIVE POWER for the stacker crane is produced by three electric motors rated at about 1½ hp each. One motor propels the crane sidewise by driving rubber-tired traction wheels that ride the bottom flanges of the crane rails. The second motor powers a similar forward-and-backward travel mechanism.

The third motor operates a constant-feed hydraulic pump mounted at the base of the stacker. This pump develops 1500 psi to drive a hydraulic cylinder which moves the operator and fork carriage up and down. A 5-in. ID vertical cylinder pulls down on a pulley system and raises the carriage as much as 15 ft. The stroke of the cylinder is less than half the actual lift.





Choosing and Using

RUBBER-BASE ADHESIVES

PROPERTIES of rubber adhesives vary with the types of polymers which form the adhesive bases. Most of these polymers or rubbers, both natural and synthetic, are thermoplastic and therefore are suitable for a variety of applications.

Versatility of a rubber-base adhesive is increased by compounding with additives which are either thermoplastic or thermosetting. Substantial differences in tack range, heat resistance, strength, and adhesion are thus obtained. Compounding materials also cause considerable variation in flexibility, elasticity, and strength of the adhesive. Nitrile-rubber adhesives, for example, can be made to show properties which range from high tackiness and low peel and shear strengths to poor tackiness and high peel and shear strengths.

Compounding Materials: In some instances, fillers are necessary to reduce tackiness of the binder for ease of handling precoated surfaces. Fibrous fillers, such as asbestos, permit application of greater thicknesses of the material where desirable. Drying rate of the adhesives is also improved by addition of fillers. Other additives include:

1. Plasticizers which are intended primarily to decrease brittleness, improve resiliency and, in some cases, im-

Table 1—Properties of Rubber-Base Adhesives

Adhesive Base	Adhesive Form	Bonding Methods	Solvent	Shear Strength* (psi)	Peel Strength* (lb per in. width)	Temperature Limits (deg F)	Resistance	
							Water	Oil
Thermoplastic Rubbers:								
Natural	Solvent, water dispersed	Solvent release, hot and cold vulcanization, water evaporation	Hydrocarbons	30 to 180	0.5 to 5	—20 to 120	Excellent	Poor
Reclaimed	Solvent, water dispersed	Solvent release, hot and cold vulcanization, water evaporation	Hydrocarbons	50 to 175	5 to 15	—30 to 180	Excellent	Poor
Neoprene	Solvent, water dispersed	Solvent release, hot and cold vulcanization, water evaporation	Ketones and esters	150 to 900	10 to 30	—40 to 200	Excellent	Excellent
Nitrile	Solvent, water dispersed	Solvent release, water evaporation	Ketones and esters	150 to 2000	15 to 50	—60 to 250	Excellent	Excellent
GRS	Solvent, water dispersed	Solvent release, hot and cold vulcanization, water evaporation	Hydrocarbons	30 to 180	3 to 12	—20 to 200	Excellent	Poor
Thermosetting Rubbers:								
Neoprene-phenolic	Liquid	Heat and pressure: 300 to 500 F at 50 to 200 psi	Ketones and esters	300 to 500 uncured, 500 to 1200 cured	20 to 35	—70 to 200	Excellent	Excellent
Nitrile-phenolic	Liquid	Heat and pressure: 300 to 500 F at 50 to 200 psi	Ketones	300 to 500 uncured, 1000 to 4000 cured	15 to 30	—60 to 400	Excellent	Excellent

*Rubber-to-metal properties at room temperature

Adhesive bonding is gaining in popularity as a simple and economical method of joining rubber and other materials. Selection of the right adhesive must be based on a knowledge of

- **Thermoplastic and thermosetting adhesives**
- **Effects of additives on bond properties**
- **Industrial applications**

By R. K. HUMKE
Manager, Technical Service Dept.
Adhesives, Coatings & Sealers Div.
Minnesota Mining & Mfg. Co.
Detroit, Mich.

prove adhesion of the compounds by allowing better wetting of surfaces.

2. Tackifying agents, including natural or synthetic resins, which are added to improve adhesion to various types of surfaces.
3. Stabilizing agents which are added to adhesive formulations to improve resistance of the base material to heat, light, and chemical breakdown.

A few rubber-base adhesives are available that do not contain additives, but these find application in low-strength bonding only.

Adhesive Solvents: The majority of elastomeric adhesives contain from 40 to 80 per cent solvent by volume which is necessary for putting the basic materials in a form which permits easy application. The solvents volatilize to deposit a uniform film of adhesive. The proper solvent for any adhesive compound will dissolve or disperse the rubber ingredients, allow convenient application, and volatilize rapidly enough to be practical for production or assembly requirements. Petroleum or naphtha type solvents are widely used for natural rubber and reclaimed-rubber adhesives. Aromatic hydrocarbons are used with neoprene compounds; and ketones, esters, or the chlorinated solvents are used with the nitrile types.

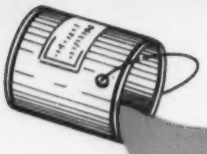
Adhesive Forms: Liquid rubber-base adhesives are available in a variety of solvent types, as water dispersions, or as vulcanizing types. Bonding is accomplished by solvent release, water evaporation, or vulcanization. Use of an elastomer such as polysulfide or natural rubber dispersed in water is advantageous from a cost and handling standpoint. The principal drawback of water dispersions, however, is their tendency to corrode certain metal surfaces to which they are applied.

High-strength adhesives are available in vulcanizing types which are either fast or slow curing. Fast-curing adhesives require heat and pressure and develop optimum bond strength in approximately 20 min at 300 F. Slow chemical-curing types are usually mixed at time of application and do not require heat. Properties of rubber-base adhesives are shown in Table 1.

to Hydrocarbons	Solvents	Suitable Adherends
Poor	Poor	Rubber to: leather, paper, wood, felt, fabrics, phenolic plastics, natural rubber, metals, glass, ceramics, tile, masonite
Poor	Poor	Rubber to: paper, wood, felt, fabrics, phenolic plastics, reclaimed rubber, metal, glass, ceramics, tile, sponge rubber
Good	Fair	Rubber to: leather, sponge rubber, neoprene rubber, plastics, metal
Excellent	Fair	Rubber to: nitrile rubber, metal, vinyl plastics
Poor	Poor	Rubber to: GR-S rubber, metal, foils (metal), fabrics
Excellent	Fair	Rubber to: rubber, metal, plastic, wood, glass, ceramics, tile, Masonite
Excellent	Good	Rubber to: rubber, metal, vinyl plastic, phenolic plastics, wood, glass, ceramics, tile, Masonite

Adhesive Applications

Because adhesive bonds are rather inconspicuous in the majority of applications, they are not usually considered in design as readily as other, more common methods of fastening. However, their use is becoming more wide-spread and the following ap-



Thermoplastic and Thermosetting

Rubber-base adhesives are classified according to the types of materials with which they bond, their actual bonding temperature, their general bonding classifications, or according to their main constituent which is the most convenient means for describing the adhesive properties. The following thermoplastic types represent those in common use today.

Natural-Rubber Adhesives: These adhesives are in the form of a natural latex stabilized to retard coagulation and sometimes modified with dispersions of synthetic elastomers. They are of a light color, translucent, and are used to bond sponge rubber to itself or to metals. They are also used to bond natural rubber to leather, paper, wood, felt, fabrics, phenolic plastics, metals, and other materials.

Natural-rubber adhesives have good dynamic strength properties but lack the ability to sustain a constant load for long periods of time. They exhibit excellent tack and water resistance but poor resistance to oil, gasoline, and heat. They have good cold resistance and fair aging characteristics at normal temperatures.

Natural-rubber adhesives in solvent solutions or water dispersions lose much of their strength at 120 F and crystallize at approximately −20 F. Above 160 F, the polymer permanently softens. Water-dispersed adhesives are subject to destruction by freezing or evaporation and coagulate gradually upon standing and exposure.

Also available in vulcanizing types, these natural-rubber adhesives require heat to establish a bond or can be cured at room temperature. Room-temperature curing, actually curing by release of exothermic heat, takes place after two parts of the adhesive are mixed at time of application. Vulcanized bonds are usable over a wider temperature range than solvent-solution types and have higher bond strengths. These bonds have very good moisture resistance and are not affected by mold or fungus. The adhesive is stable and shelf life is good. Natural-rubber adhesives generally exhibit excellent tackiness and tack retention. Coated surfaces can be kept for many weeks and then bonded securely with minimum pressure.

Short-tack natural-rubber adhesives have shear strengths from 30 to 180 psi but flow under constant high stress. Short-tack solvent-solution adhesives offer short exposure times before bonding, while short-tack water dispersions develop little tack and should be bonded while wet.

Long-tack natural-rubber adhesives are used for temporary bonds which are not subjected to stress. They have a tendency to flow even under low loads. Long-tack water dispersions differ from long-tack solvent-solutions in that they don't retain as much tack but develop more strength and greater resistance to flow. Although long-tack adhesives have very little resistance to solvents, fuels, or lubricating oils, they have good resistance to many of the plasticizers used in sheet-vinyl materials.

Because natural-rubber adhesives are oil-soluble elastomers, they will deteriorate when exposed to naphtha and other petroleum-derived solvents. Natural rubber is also subject to deterioration upon prolonged exposure to sunlight.

Reclaimed-Rubber Adhesives: Because of their characteristic low cost, good physical properties, wide tack range, tolerance of surface preparation, and high wet strength, reclaimed-rubber adhesives are the most widely used of the rubber-base types. They are used to bond rubber to paper, wood, felt, fabrics, phenolic plastics, rubber, tile, metals, and other material. Since these adhesives are usually based on reclaimed natural rubber, their properties are similar to those of the parent elastomer.

Reclaimed-rubber adhesives differ radically from each other in strength, heat resistance, and tack range because they are modified with tackifying resins and, in some cases, with fillers, antioxidants, and other materials. Depending on materials bonded and the method of bonding, most adhesives of this type provide shear strengths of 50 to 175 psi at normal room temperatures. They have good peel and shear strengths and ability to withstand high humidities. These adhesives, however, creep and fail under relatively low dead-load stress.

These adhesives have the best tack range of any of the rubber-base types. They are the most tolerant of surface conditions, have high wet-strength and long can life. They will maintain a strong bond through a service temperature range from −30 to 180 F.

Because reclaimed-rubber adhesives are thermoplastic, strength decreases as temperature increases. They have good water resistance and dry to a firm, tough, rubbery film. However, bonds deteriorate when exposed to gasoline, oils, or other solvents. Like unvulcanized natural-rubber adhesives, they lose much of their strength at about 180 F and become brittle around −30 F depending upon the resin in the formula. Some reclaimed adhesives maintain strong bonds at temperatures as high as 500 F for short periods of time.

Reclaimed adhesives are soluble in hydrocarbon solvents and are affected by most of the common solvents. Like natural-rubber adhesives, reclaims deteriorate at elevated temperatures and will not stand up well when exposed to sunlight. These adhesives are available in both water dispersions and solvent solutions.

GR-S-Rubber Adhesives: Butadiene-styrene copolymers are similar to natural rubber in compounding characteristics, elasticity, strength, and lack of oil resistance. GR-S adhesives are used for bonding rubber to rubber, fabrics, and metal. Properties closely resemble those of the natural and reclaimed-rubber adhesives. Solvent adhesive types are useful in lamination and for installing insulation materials and trim fabrics.

GR-S rubber adhesives offer two advantages over natural and reclaimed types. They have superior aging characteristics and are not as rapidly deteriorated by exposure to elevated temperatures. Temperature aging of GR-S results in a stiffening and toughening of the rubber whereas natural rubber softens.

Dead-load properties are superior to those of the reclaimed materials. GR-S rubber adhesives are considerably more susceptible to creep and plastic flow than the neoprenes. Compared to other rubber-base adhesives, GR-S types have fair strength properties, poor dead-load properties, fair tack, excellent water resistance, poor resistance to oil and gasoline, fair heat resistance, good resistance to cold, and fair aging qualities. They are available in both solvent and latex form, and are often compounded with tackifiers and plasticizing oils.

Neoprene-Rubber Adhesives: These adhesives have high resistance to aliphatic solvents, acids, alkalies, heat, and sunlight and provide strong bonds between most synthetic rubbers and metals. They are considered the most versatile of the low-cost adhesives commonly in use today. They have excellent strength properties, good dead-load and tack properties, excellent resistance to water, good resistance to oil, gasoline, heat, and cold, and good aging properties.

The neoprenes are superior in their ability to sustain continuous stress loads without failure. While they are not as good as straight thermosetting adhesives, some can support more than 100 psi for extended periods of time. Some neoprene-base formulas will sustain low loads at elevated temperatures soon after bonding. This property is important if bonds are to be made prior to a paint-bake cycle. Although neoprene adhesives are not generally recommended for continuous service above 200 F, some formulations withstand relatively low loads for short periods of time at temperatures as high as 350 F.

The neoprenes are used to bond most rubbers to leather, steel, malleable iron, stainless steel, brass, aluminum, magnesium, titanium, and other materials. Physical and chemical properties can be varied considerably according to additives used.

Most neoprene adhesives are solvent types, although

Rubber-Base Adhesives

water dispersions or latex types are also available. Two-part chemically-curing neoprene adhesives are available to provide specific tack, chemical resistance, and strength properties.

Some of the strong neoprene adhesives gain part of their strength through evaporation of solvent followed by crystallization of the neoprene and curing of the elastomer for varying periods of time. Rate of strength build-up with the neoprenes is rapid. Immediate bond strength increases as drying time is prolonged up to the point where the adhesive is so dry that a bond can no longer be obtained.

Some neoprene adhesives have contact-bond properties. In contact bonding, the adhesive is dried until it appears to have no tack at all. When coated components are pressed together, the bond is excellent and supports a considerable amount of stress immediately.

In general, neoprene adhesives are not as shelf stable as reclaimed rubber or GR-S formulations, but some compounds still possess good application properties even after storage for one year.

Nitrile-Rubber Adhesives: These adhesives contain copolymers of butadiene and acrylonitrile and have high strength, excellent aging properties, and good chemical resistance. They resist aliphatic solvents and many plasticizers which cause bond failure of other adhesives and are especially suited for bonding synthetic rubber to metal.

Nitrile adhesives have excellent strength, fair dead-load properties, good tack, excellent resistance to water, oil, and gasoline, good resistance to heat and cold, and good aging characteristics. These adhesives have less resistance to water than neoprene adhesives but greater resistance to fuels, lubricating and plasticizing oils, and aromatic fuels and oils.

Nitrile-rubber adhesives are used to bond rubber to vinyl plastics and for bonding nitrile and neoprene rubbers to steel, malleable iron, stainless steel, brass, aluminum, magnesium, and titanium. They can be used for practically the same materials as other rubber-base adhesives but because of higher cost and slightly more difficult handling, are chosen only when some of their desirable properties are needed.

Chemical resistance of nitrile adhesives permits bonding of adherends which contain migrating plasticizers. Hence, nitriles are commonly used for bonding unsupported vinyl film because bond strength is adequate and softening action of the plasticizers which may leach from the film is resisted. Nitriles are also used for bonding rubbers compounded for low-temperature flexibility.

Nitrile adhesives maintain adhesion and flexibility in thin films in a temperature range from −65 to 250 F. Where strength requirements are low, they can be used at temperature to 250 F. Generally, adhesives of this type which have the best heat resistance usually have the shortest tack range.

Thermoplastic nitriles maintain good loads to 160 F. In some cases, these adhesives even gain strength at that temperature, depending on the resins used. Shear strengths range from 150 to 2000 psi.

Nitrile rubber is an oil-resistant elastomer. Because ketones or esters must be used to produce solvent solutions, bonding with these adhesives to painted surfaces must be done carefully because these solvents affect most paints.

Nitrile adhesives are less tacky than either the reclaimed rubber or the neoprene types and usually dry completely tack free. They are nonblocking and can be applied to parts which can be stored until ready for actual bonding operations. The adhesive is then reactivated and bonding completed. Only enough pressure to insure contact is needed to produce the bond.

Nitriles are available as solvent solutions or water dispersions. Solvent solutions with modifying resins make one of the toughest and most versatile types of thermoplastic adhesives. Like other rubber-base adhesives, they are almost always compounded with modifying ingredients. In instances where solvent may attack the adherends, the nitrile-latex water-dispersed adhesive should be considered.

Thermosetting Adhesives

Thermosetting resins are often added to synthetic-rubber adhesives to produce high strength, good adhesion to a wide variety of materials, and flexibility. The resin gives added strength to the adhesive, and the elastomeric base retains most of its original adhesion and flexibility properties. Although these adhesives are mainly used for bonding metal to metal and other nonporous surfaces, they are sometimes used in bonding rubber to rubber and other adherends. Two of the most popular types of thermosetting rubber adhesives are the neoprene phenolics and nitrile phenolics.

Neoprene-Phenolic Adhesives: These are sometimes referred to as high-performance, general-purpose adhesives because of the variety of bonding jobs which can be done with them. They contain thermosetting resins which allow the adhesives to be heat cured, thus improving their inherently good heat resistance and bond strength. Uncured neoprene phenolic adhesives have bond strengths from 300 to 500 psi in shear, but heat curing increases them to 500 to 1200 psi.

Neoprene-phenolic adhesive compounds have good fatigue and impact strengths, fair to moderate creep resistance, and excellent resistance to water, oil, grease, and hydrocarbons. Because of good resistance to creep and cold flow, they can sustain relatively high continuous loads for long periods of time. They are excellent adhesives for both structural and non-structural assemblies. They retain useful strength properties after exposure to hot water, gasoline, and glycol. Normally, these adhesives can be used at temperatures from −70 to 200 F with strengths at the upper limit equal to half those at room-temperature.

Cured neoprene-phenolic bonds are more rigid than those of thermoplastic modifications but are not quite as rigid as well-cured unmodified phenolic-resin bonds. Because these adhesives are somewhat elastic, they elongate or deform slightly under stress which allows stress distributions within the bond.

Neoprene phenolic adhesives are used to bond rubber to rubber, wood, and many plastics usually in large structural applications.

Nitrile-Phenolic Adhesives: Like the neoprene-phenolics these are also considered as high performance, general-purpose adhesives. The thermosetting resins which they contain are responsible for shear strengths from 1000 to 4000 psi for the cured adhesive. Bond strength of the uncured adhesive is comparable to that of the neoprene phenolics.

Nitrile-phenolic adhesives are characterized by good elevated-temperature strength, which is retained to 400 F. However, they can be used at temperatures from 500 to 600 F if exposure is intermittent and the bond is shielded from direct air contact. These adhesives also have good fatigue properties, good resistance to cold flow and creep, excellent shear and peel strengths, and good impact strength. They have excellent resistance to water, oil, grease, and hydrocarbons, and good resistance to solvents.

Nitrile phenolics are used to bond rubber to rubber, wood, vinyl plastics, phenolic plastics, and metal. They are available in both liquid and film forms. Liquid adhesives can be sprayed, brushed, roll coated, or extruded on the adherends. Liquid nitrile-phenolics must be dried to a tack-free state after application and then cured with heat and pressure. Adequate cure can be obtained at 325 F in approximately 20 minutes. However, better strengths are obtained if the adhesives are cured at 350 to 500 F at 50 to 200 psi.

plications indicate to some extent their acceptance in various industries.

Automotive Use: Neoprene-rubber adhesives are used in the automotive industry to bond sponge rubber or solid rubber weatherstrip to lacquered or enameled metal doors and frames. These adhesives have high strength, good adhesion, and permanence when exposed to the weather. A wide variety of adhesives is available for this application. Some can be sprayed on, some roll coated, and all can be brush-applied. All weatherstrip adhesives produce a strong bond between the metal and rubber, have excellent resistance to temperature extremes and moisture, good aging properties, and they do not stain the painted metal surfaces to which they are applied.

Reclaimed-rubber adhesives are used for bonding rubber pads and insulating materials to the roof, floor, and under hoods of automobiles. These adhesives gain strength rapidly and have good properties at operating temperatures. They are also used for bonding cloth, vinyl, or leather to asphalt-impregnated board, steel, and other surfaces in bodies. This class of adhesives is used because of low cost, ease of application, rapid gain in strength, and long bonding range.

Rubber-resin adhesives are used for bonding friction materials to metal shoes in brakes and clutches on automobiles, trucks, and airplanes. Elimination of holes for rivets has greatly increased effective braking area without increasing brake size. Longer lining life is gained because linings can be worn thinner without danger of scoring the drums by rivet heads.

Neoprene or reclaimed-rubber adhesives are used as trim adhesives for bonding a variety of trim to metal, wood, and other surfaces. These adhesives provide an exceptionally strong bond for many types of vinyl applied to body interiors. They are resistant to plasticizers present in vinyls and thus assure a permanent bond.

Rubber-base adhesives are important in interior styling. They provide excellent adhesion between trim and base materials and do not strike through fabrics or leave stains. Also, they are highly resistant to heat. This is important because, in many instances, rubber weatherstrip is bonded to painted surfaces before the final paint bake cycle. Rubber-base adhesives for these applications can be applied by spray gun, by brush, or by roller coating.

Aircraft Use: Oil-resistant neoprene or nitrile-rubber adhesives are used to bond neoprene tubing, sheeting, foam, and gaskets to themselves and to plastic and metal surfaces. Because of ease of application, neoprene adhesives are used for bonding neoprene-rubber gaskets around windows and canopies, vinyl trim fabrics to metal, leather to wood, and vinyl facings to fibrous glass insulation.

Special purpose rubber-resin adhesives are used for bonding cured nitrile-rubber patches to cured nitrile-rubber liners in self-sealing and collapsible fuel cells. In this application, the bond must not deteriorate even after several years of constant immersion in aromatic fuels. Another example of rubber-resin adhesive use is in the bonding of a nylon barrier in self-sealing fuel cells to a natural rubber or GR-S sealant.

Nitrile-rubber adhesives which have high resistance to water, oil, and aromatic fuels, are used for bonding nitrile-rubber tubing, foam, sheeting, and gaskets to themselves and to metals in areas which are in direct contact with aromatic fuels.

Oil and fuel resistant adhesives, such as the nitrile rubbers, can be used for almost any aircraft bonding application except in high-strength metal-to-metal bonds. They are used in most repair work and are the most nearly general purpose adhesives known in industry. They are not resistant to continuous immersion in aromatic fuels but their resistance to aliphatic types is excellent.

Reclaimed and GR-S rubber adhesives are used to bond felt, fabric, wood, asbestos, and paper to themselves and to aluminum surfaces. Both types of adhesives use relatively inexpensive elastomers and solvents. These formulations have good resistance to water and generally adequate weathering characteristics. In many instances, rubber-resin adhesives are used to bond paper and aluminum honeycomb and other core materials to plastic, aluminum, and steel skins.

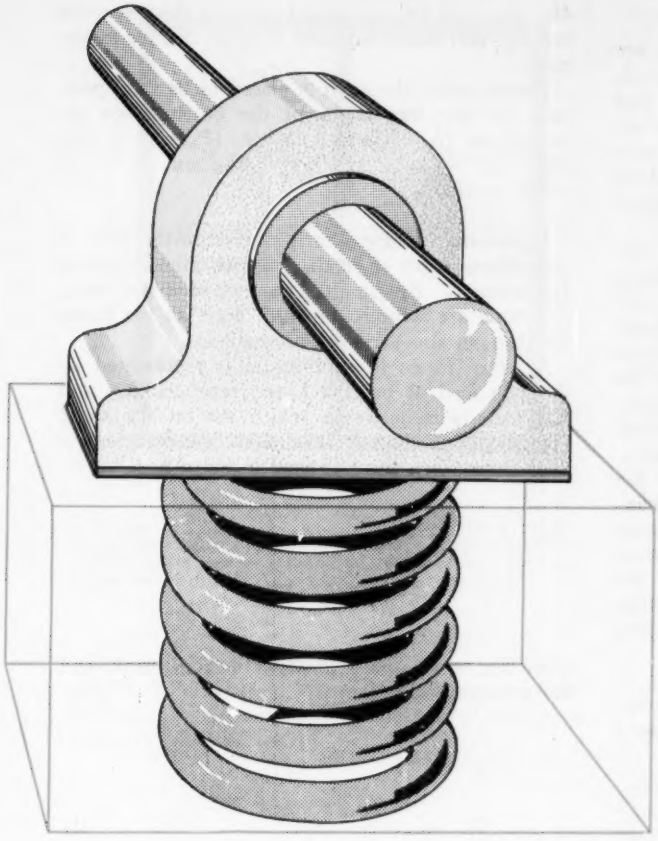
Adhesives for Trucks and Buses: Rubber-base adhesives are used in the truck and bus industry in applications similar to those of the automotive industry. Reclaimed-rubber adhesives are used for bonding rubber and linoleum mats to truck floors. Rubber window channels are bonded to painted steel bus frames with adhesives which withstand extremes of weather, heat, water, oils, and effects of time.

Sound and vibration dampening pads are bonded to truck cab tops with reclaimed-rubber adhesives. These can be sprayed on the sheet metal without removing the metal's protective oil film. The pad is then placed in position and bonds instantly.

Adhesives for Refrigeration and Air Conditioning Units: Neoprene-rubber adhesives are used for bonding rubber gaskets to access-door frames, covers, and to metal or plastic parts on air conditioners. They develop aggressive tack and hold the gaskets firmly in place as soon as the bond is completed. They have good water resistance and adhere well to metal, painted surfaces, and molded rubber. Fibrous glass insulation is bonded to metal on the inside of ice-making machines with reclaimed-rubber adhesives.

Nitrile-rubber adhesives are used to bond Masonite discs to metal compressor housings. This enables manufacturers to cut assembly costs by eliminating other fastener types.

A water-dispersed GR-S adhesive is used to bond fibrous glass insulations to a plastic trim frame. Because the adhesive is a water dispersion, there is no fire hazard, and it is nonstaining to the plastic. Rubber-base adhesives used to bond fibrous glass to steel are resistant to high temperatures.



Support-spring analogy

simplifies solution of indeterminate

Shaft and Bearing Loads

By M. F. SPOTTS
Professor of Mechanical Engineering
Northwestern University
Evanston, Ill.

FAILURES in shaft and bearings assemblies are often caused by unexpected forces induced by changes in bearing elevations. These elevation changes occur when elastic or spring-like bearing supports deform under load and set up deflections at the bearings. This analysis uses the spring-like properties of the supports to simplify deflection and load calculations, enabling designers to quickly determine possible trouble spots.

Two types of shaft and bearing assemblies must be considered: Single span, or shafts carried by only two bearings, and multiple span, or continuous shafts carried by three or more bearings. Since deflections at the supports of single-span systems have no effect on bearing loads, these assemblies are excluded from this analysis.

Continuous shaft arrangements are indeterminate, and deflections at the bearings frequently cause a wide redistribution of forces and stresses throughout the entire system. Even so, adjustments can frequently be made in indeterminate designs to equalize bearing loads or reduce shaft stresses at vital points.

Analysis: To obtain true values for bearing reactions and bending moments, calculations must account for the flexibility of supports. To do this, it is convenient to use the spring rate or spring constant of a support. The spring constant, k, is the force required to cause a unit deflection of the spring. When the deflection y equals unity, load P equals k,

Nomenclature

b = Distance from shaft load to nearest support, in.
d = Shaft diameter, in.
h = Distance from bottom of unstressed springs at end bearings to lower support, in.
k = Spring constant, lb per in.
l = Length, in.
P = Bearing load, lb
R = Reaction, lb
W = Shaft load, lb
y = Downward deflection, in.
Δ = Upward deflection, in.
δh = Fill, in.

For reactions, first subscript refers to location of reaction and second subscript refers to point of load application

and the bearing deflection equals P/k.

Flexible supports for the continuous shaft are represented schematically, Fig. 1, by helical springs, whose unstressed lengths are the same. End bearings are designated A and B, and intermediate bearings are numbered 1, 2, and 3. The lower support for the springs is assumed to be unyielding. When the shaft is in its final position, the springs carry loads P_A, P_B, P_1, P_2, and P_3.

Assume that the springs are temporarily disconnected at the lower support, and that forces are applied at A and B to raise the shaft sufficiently to produce a distance h between the bottoms of the unstressed springs at A and B and the lower support. Then, when the shaft is lowered to the support, movement of bearing A is $h + P_A/k_A$, where P_A/k_A is the elastic deflection of the spring. It follows that movement of bearing B is $h + P_B/k_B$.

If the shaft were rigid, the distance from the ends of the intermediate springs to the lower support would also be h. Actually, however, the loads on the shaft cause deflections of y_1, y_2, and y_3 when the shaft is in the raised position. Therefore, the distances from the end of the intermediate springs to the lower support are $h - y_1$, $h - y_2$, and $h - y_3$.

When the shaft is in its final position, Fig. 1, forces acting in the intermediate springs cause upward deflections of the shaft. These total upward deflections are designated as Δ_1, Δ_2, and Δ_3. Fills δh_1, δh_2, and δh_3 are placed between the respective bearings and elastic supports to adjust bearing movement.

Hence, when the shaft is placed in its final position, the net movements of the bearings are expressed as $(h - y_1) + \Delta_1 + (P_1/k_1) - \delta h_1$, $(h - y_2) + \Delta_2 + (P_2/k_2) - \delta h_2$, and $(h - y_3) + \Delta_3 + (P_3/k_3) - \delta h_3$.

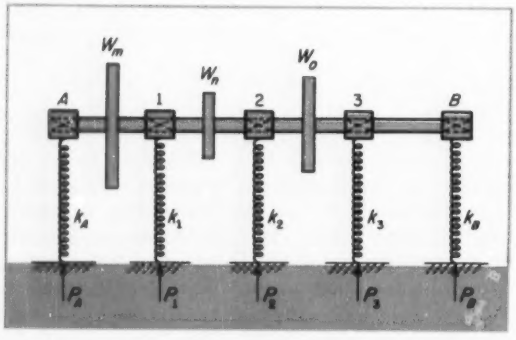


Fig. 1—Schematic of indeterminate shaft and bearing assembly. Elastic supports represented by helical springs

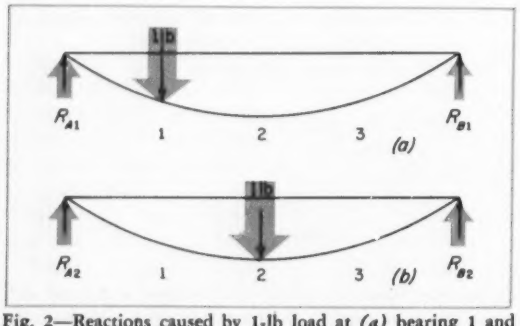


Fig. 2—Reactions caused by 1-lb load at *(a)* bearing 1 and *(b)* bearing 2

Equations: These bearing movements give to the system a set of small, geometrically consistent deformations. By using the theorem of virtual work, equations are written for work done as the forces act through the various deformations.

A set of forces in equilibrium is represented by the 1-lb load at bearing 1 and reactions R_{A1} and R_{B1} (see Nomenclature) which act on the shaft, Fig. 2*a*. Observing algebraic signs, the equation for work done when the 1-lb load is added is

$$R_{A1}\left(h + \frac{P_A}{k_A} - \delta h_A\right) + R_{B1}\left(h + \frac{P_B}{k_B} - \delta h_B\right) = (h - y_1) + \Delta_1 + \frac{P_1}{k_1} - \delta h_1$$

Since $R_{A1} + R_{B1} = 1$ lb, $R_{A1}h + R_{B1}h = h$, and the equation reduces to

$$R_{A1}\left(\frac{P_A}{k_A} - \delta h_A\right) + R_{B1}\left(\frac{P_B}{k_B} - \delta h_B\right) = \Delta_1 - y_1 + \frac{P_1}{k_1} - \delta h_1 \qquad (1)$$

Similarly, the shaft, Fig. 2*b*, carries a 1-lb load at bearing 2 and reactions R_{A2} and R_{B2}. The equation for this loading is

$$R_{A2}\left(\frac{P_A}{k_A} - \delta h_A\right) + R_{B2}\left(\frac{P_B}{k_B} - \delta h_B\right) = \Delta_2 - y_2 + \frac{P_2}{k_2} - \delta h_2 \qquad (2)$$

In a similar manner, equations can be written for each of the indeterminate locations. In addition, two equations from statics can be written for the shaft, Fig. 1: One for summation of forces, and one for summation of moments. The virtual work equations, plus the two equations from statics, are equal in number to the number of unknowns and can be solved simultaneously for any one of the unknown values.

Example 1: A drive frame, Fig. 3, made of structural beams*, carries the continuous shaft and two loads, and is supported at the four corners. The tops of all beams are of the same elevation after frame fabrication, but before loads are applied to the assembly. Determine the bearing reactions. Neglect dead loads, and assume that all beams are simply supported.

*Members are designated in accordance with AISC recommendations included in *Steel Construction Manual*, American Institute of Steel Construction, New York, 1956.

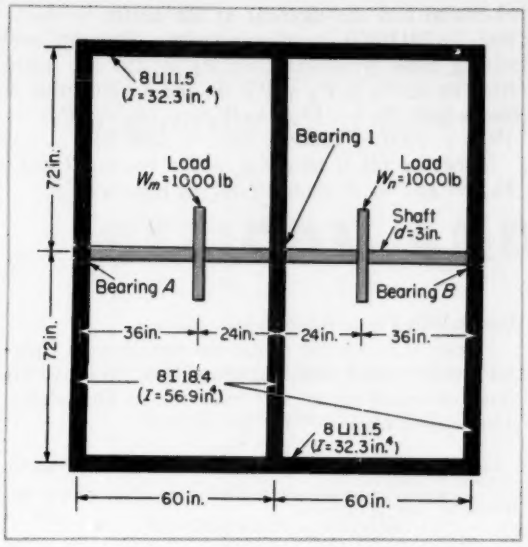


Fig. 3—Drive frame of structural beams. Supported at four corners, frame carries continuous shaft on three bearings. Beams are of same elevation before loads are applied

Moment of inertia for the shaft is $I = \pi d^4/64 = \pi 3^4/64 = 3.9761$ in.^{4} When the shaft is raised from the bearings, the downward deflection at bearing 1 due to $W_m = 1000$ lb is

$$y = \frac{W b x}{6 l E I}(l^2 - b^2 - x^2)$$

$$= \frac{1000(36)(60)(120^2 - 36^2 - 60^2)}{6(120)(30)(10^6)(3.9761)} = 0.23903 \text{ in.}$$

and the total downward deflection at bearing 1 due to both loads W_m and W_n is $y_1 = 2y = 0.47806$ in. The upward deflection at bearing 1 due to the unknown force P_1 is

$$\Delta_1 = \frac{P_1 l^3}{48 E I} = \frac{120^3 P_1}{48(30)(10^6)(3.9761)} = 0.0003018 P_1$$

Spring constants for bearing supports A and B are equal and are found by placing the total deflection of the shaft equal to unity when the load becomes equal to the spring constant:

$$1 = \frac{k_A l^3}{48 E I} = \frac{k_B l^3}{48 E I}$$

or

$$k_A = k_B = \frac{48EI}{l^3} = \frac{48(30)(10^6)(56.9)}{144^3} = 27{,}440 \text{ lb per in.}$$

For the spring constant of the support at bearing 1, the procedure is a little different. Since the center I-beam deflects in series with the end channels, k_1 depends upon the stiffness of all three members, and is found by placing a 1-lb load at bearing 1. The deflection of the I-beam is $y_I = P_I/k_I = 1/27{,}440 = 0.00003644$ in. The load at the center of each end channel of 0.5 lb and the corresponding deflections are $y_{Ch} = Pl^3/48EI = 0.5\ (120^3)/48(30)(10^6)(32.3) = 0.000018516$ in. Hence, total deflection at bearing 1 is

$$1/k_1 = 1/k_{I\_beam} + 1/k_{channel}$$

$$= 3.6443(10^{-5}) + 1.8576(10^{-5}) = 5.502(10^{-5}) \text{ in. per lb}$$

and the spring constant is

$$k_1 = \frac{1}{5.502(10^{-5})} = 18{,}176 \text{ lb/in.}$$

With the 1-lb load at 1, $R_{A1} = R_{B1} = 0.5$ lb, and all fills, δh, are assumed zero. From Equation 1,

$$\frac{0.5 P_A}{27{,}440} + \frac{0.5 P_B}{27{,}440} = 0.0003018 P_1 - 0.47806 + \frac{P_1}{18{,}176}$$

which, since $P_A = P_B$ by symmetry, reduces to

$$0.000036443 P_A - 0.00035682 P_1 = -0.47806$$

or

$$0.10213 P_A - P_1 = -1399.8 \text{ lb} \quad (3)$$

From summation of forces acting on shaft, Fig. 4,

$$2 P_A + P_1 = 2000 \text{ lb} \quad (4)$$

and simultaneous solution of Equations 3 and 4 gives $P_A = P_B = 314.1$ lb. Substituting this value in Equation 4 gives $P_1 = 2000 - 2(314.1) = 1371.8$ 1371.8 lb. The drawing, Fig. 5, shows that the deformed shape of the shaft fits the final elevations of the bearings.

The virtual work equations can also be adjusted to help solve problems in which relationships between bending moments or bearing reactions are specified.

Example 2: Find the thickness of fill that must be placed under bearing 1, Fig. 3, to make the shaft bending moments at the loads and at the center of each span equal.

From statics, the moment at the loads, $M_L = 36P_A$

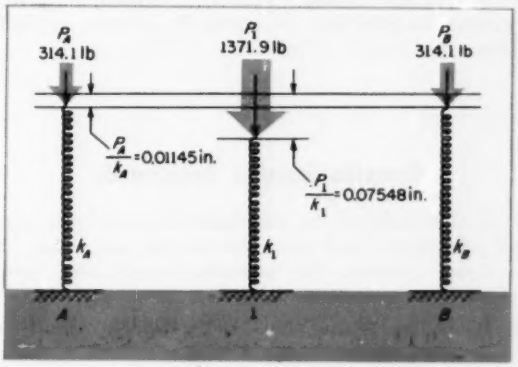


Fig. 4—Frame loading diagram. Compression of springs shows elastic deflection of frame

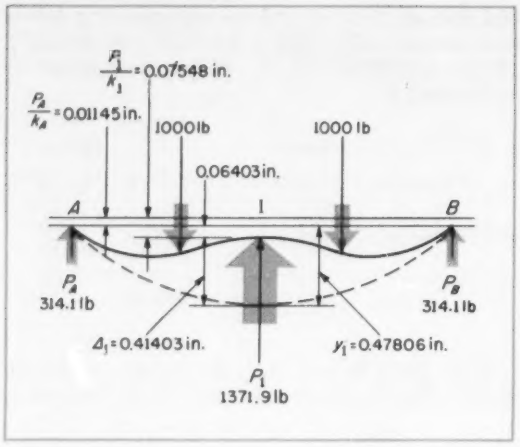


Fig. 5—Shaft loading diagram. Deflection of shaft must match deflection of frame to prevent shaft and bearing failures

clockwise and the moment at the center is $M_C = 60P_A - 24(1000)$ counterclockwise. Equating and solving these equations gives $P_A = 250$ lb. Again from statics $P_B = P_A = 250$ lb, and a summation of forces gives $P_1 = W_m + W_s - (P_A + P_B) = 1000 + 1000 - (250 + 250) = 1500$ lb.

Since the fill is to added under bearing 1 only, $\delta h_A = \delta h_B = 0$. Substituting in Equation 1,

$$\frac{250}{27{,}400} = -0.47806 + 0.0003018(1500) + \frac{1500}{18{,}176} - \delta h_1$$

from which $\delta h_1 = 0.04806$ in.

Hence, it is possible to use the virtual work equations to exercise a certain amount of control over the final values of forces and moments in an indeterminate system.

EDITOR'S NOTE

Another method for solution of indeterminate shaft and bearing problems is contained in:
A. J. Scalzo—"Misalignment Moments," MACHINE DESIGN, November 13, 1958, pp. 157-160.

Tips and Techniques

Sphere Dimensions

A standard slide rule is used to find the volume or diameter of a sphere quickly when the other value is known. The K scale is used to determine volumes, with the left-hand, middle, and right-hand cycles representing volumes of 1 to 10,000 in.^{3}, 10,000 to 100,000 in.^{3}, and 100,000 to 1,000,000 in.^{3} respectively. The C scale is used directly for determining diameters in inches.

To find the diameter of a sphere when the volume is known, the number 124 on the C scale is placed opposite the left index of the D scale, and hairline is placed over the value of the volume on the K scale, and the diameter is read on the C scale. For example, to find the diameter of a sphere with a volume of 3456 in.^{3}, set the C scale, place the hairline over 3456 on the K scale, and read the diameter of the sphere, 18.75 in., on the C scale.

Volumes are found from known diameters by reversing the procedure.—THOMAS E. LLEWELLYN, *Bell Aircraft, Lockport, N. Y.*

Complex Number Reciprocals

A slide rule, of the log duplex decitrig type, can be effectively used to determine the reciprocal of complex numbers. For example, the following steps show how to find the value of $1/(3 + j4)$.

1. Set the index of the slide on the larger number, 4, on the D scale.
2. Slide the indicator to the smaller number, 3, also on the D scale.
3. Read the angle opposite the hairline on the tangent scale.
4. Slide the slide until the angle obtained in step 3 is opposite the hairline on the sine scale.
5. Slide the indicator to the smaller number, 3, on the A scale and read the number, 12, found on the B scale opposite the hairline.
6. Leaving the slide alone, slip the hairline along to the larger number, 4, on the A scale and read the number, 16, on the B scale.

Since the sign of the imaginary term was plus in the denominator, the sign is changed to minus, and the answer is $0.12 - j0.16$. The decimal point is found by estimation.—CHARLES M. GILLESPIE, *assistant engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.*

Dividing Tip

Increased slide rule accuracy for division problems, such as b/a, when b is larger than a, is obtained from this method. Divide the difference $(b - a)$ by (a), and add one (1) to the quotient.

Example: Divide 107 by 103, letting $b = 107$ and $a = 103$. Therefore, $(b - a)/a = 4/103 = 0.03883$. Add one to this value to obtain the answer, 1.03883. The actual value is 1.038834. —BILLY B. BOWLES, *Chemstrand Corp., Decatur, Ala.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Equations and tables for initial design of

HELICAL AND BEVEL GEARS

. . . a method for rapidly finding approximate gear dimensions from either wear or bending limits

By DONALD J. MYATT
Associate Professor of Engineering
Antioch College
Yellow Springs, Ohio

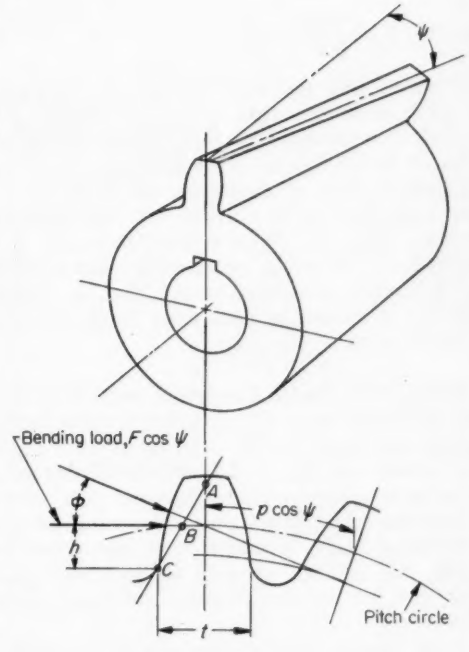


Fig. 1—Basic helical-gear tooth relationships. Distances *AB* and *BC* are equal. Lewis form factor $y = t^2/6pb$

KEY dimension in gear design is the diametral pitch. Once it is determined, other gear dimensions can be readily found, and the overall design can be analyzed and refined by more precise methods.[1]

A method for rapidly finding approximate dimensions of straight spur gears from either wear or bending limits was presented in a previous article.[2] This article presents a similar approach for estimating diametral pitch in helical and bevel gears.

Helical-Gear Relationships: The Lewis equation relates approximate bending stress at the root of a helical gear tooth in terms of tooth dimensions and torque-producing load transmitted by the tooth, Fig. 1 (symbols are defined in Nomenclature):

$$F = y p f s \cos \psi \qquad (1)$$

This equation may be modified to give diametral pitch P in terms of torque on the pinion shaft, bending fatigue strength of the pinion material, and number of pinion teeth by introducing,

$$F = \frac{2TP}{N_P}$$

$$p = \frac{\pi}{P}$$

$$s = \frac{S}{K'}$$

where $K' = 2$ will be assumed.

Assuming a practical face-width proportion equal to four times the axial pitch of the helical gear,

$$f = \frac{4\pi}{P \tan \psi}$$

[1]References are tabulated at end of article.

Substituting in Equation 1,

$$P = \left(\frac{\pi^2 y N_P S \cos\psi}{T \tan\psi} \right)^{1/3} \quad (2)$$

Buckingham[3] has proposed a formula for relating surface-fatigue load-stress factor K for gear teeth in terms of gear load, tooth dimensions, materials properties, and helix angle:

$$F = \frac{dfQK}{\cos^2\psi} \quad (3)$$

This equation can be modified to give diametral pitch P in terms of torque on the pinion shaft, load-stress factor, velocity ratio, number of pinion teeth, and helix angle by introducing the relationships,

$$F = \frac{2TP}{N_P}$$

$$d = \frac{N_P}{P}$$

$$f = \frac{4\pi}{P \tan\psi}$$

Substituting in Equation 3,

$$P = \left(\frac{6.28\, N_P^2\, QK}{T \tan\psi \cos^2\psi} \right)^{1/3} \quad (4)$$

Either Equation 2 or 4 may be used to obtain a trial value of diametral pitch for determination of initial gear proportions. Choice of which equation to use depends upon number of teeth in the pinion, quality of gear manufacture, gear materials, and type of heat treatment.

Equating Equations 2 and 4 gives an expression for number of teeth N_P' on a pinion with bending strength equal to wear strength:

$$N_P' = 1.57 \frac{yS \cos^2\psi}{QK} \quad (5)$$

Any pinion with less than N_P' teeth is more likely to fail in wear than from a repeated bending load.

Table 1 summarizes assumptions and results of a series of calculations to determine the value of N_P' for helical gears of 20-degree, full-depth-involute form with different heat treatments. Note that data for spur gears are repeated from Reference 2 for comparison. The results indicate that wear is usually the governing consideration and that, in general, Equation 4 should be used when initiating design of helical gears.

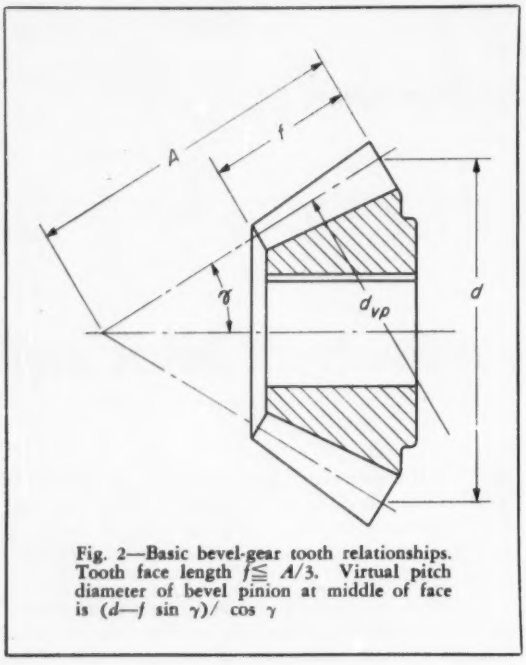


Fig. 2—Basic bevel-gear tooth relationships. Tooth face length $f \leqq A/3$. Virtual pitch diameter of bevel pinion at middle of face is $(d - f \sin\gamma)/\cos\gamma$

Nomenclature

A = Cone distance at large end of bevel gear, in.
C = Center distance, in.
D = Pitch diameter of gear, in.
d = Pitch diameter of pinion, in.
d_{vp} = Virtual pitch diameter of bevel pinion at middle of face, in.
F = Torque-producing load, lb
f = Face width of gear, in.
K = Surface-fatigue load-stress factor
K' = Gear-tooth fillet stress-concentration factor
m_G = Velocity ratio (input speed/output speed)
N_f = Formative number of teeth for helical gears
N_G = Number of teeth on gear
N_P = Number of teeth on pinion
N_P' = Number of teeth on pinion having bending strength equal to wear strength
N_v = Virtual number of teeth for bevel gears
P = Diametral pitch
p = Circular pitch, in.
Q = Ratio factor
$= 2m_G/(1 + m_G)$
S = Endurance limit in bending, psi
s = Nominal bending stress, psi
T = Torque on pinion shaft, lb-in.
y = Lewis form factor
γ = Pitch cone angle of bevel pinion, deg
ϕ = Pressure angle of gear teeth, deg
ψ = Helix angle of helical pinion, deg

Helical Gear Design Example: Input torque to the first reduction gears of a double-reduction helical-gear speed reducer is 788 lb-in. Input speed is 1400 rpm. Speed ratio $m_G = 3.5$, and the 23-deg helical gears must operate on approximately 5-in. centers. If accurate quality gears are to be used under moderate-shock loads, determine their pitch and face width, and number of teeth on gear and pinion. This unit has an electric-motor drive and operates 3 hr per day.

From Table 3, velocity factor = 1.33 and duty factor = 0.8 (1.25) = 1. Torque T = 1.33 (1.0) (788) = 1050 lb-in. Ratio factor $Q = 2(3.5)/(1 + 3.5) = 1.56$. From Table 2 for accurate gears, and assuming $\phi = 20$ deg, load stress factor $K = 150$.

Gear and pinion pitch diameters can be calculated from center distance and speed ratio values; $(D + d)/2 = 5$ in., $D/d = 3.5$. Simultaneous

Table 1—Typical Gear Specifications for Equal Strength in Wear and Bending

Specification	Commercial	Accurate	Precision
Tooth form	20-deg full-depth	20-deg full-depth	20-deg full-depth
Pinion material	Steel, 150 Bhn	Steel, 320 Bhn	Steel, 400 Bhn
Gear material	Steel, 150 Bhn	Steel, 240 Bhn	Steel, 400 Bhn
Ratio, m_G	3	3	3
Pinion teeth, N_P'			
Spur gear	98	62	39
Helical gear (ψ = 23 deg)	129	83	43
Bevel gear (γ = 18.5 deg)	98	63	33

Table 2—Gear Design Data

1. Lewis Form Factor, y

Number of Teeth*	y 14½-deg full-depth	y 20-deg full-depth	y 20-deg stub
Helical Gears			
12	0.113	0.132	0.158
28	0.170	0.190	0.219
100	0.198	0.241	0.257
150	0.202	0.248	0.264
Bevel Gears			
10	0.055	0.064	0.088
28	0.100	0.112	0.137
100	0.117	0.142	0.161
150	0.119	0.146	0.165

*For helical gears, values are formative number of teeth ($N_f = N/\cos^3\psi$); for bevel gears, values are virtual number of teeth ($N_v = N/\cos\psi$).

2. Endurance Limit in Bending, S

Material	Hardness (Bhn)	S (psi)	Gear Class
Steel	150	35,000	Commercial
Steel	240	60,000	Accurate
Steel	320	80,000	Accurate
Steel	400	100,000	Precision

3. Load-Stress Factor, K

Hardness* (Bhn)	K ϕ = 14½ deg	K ϕ = 20 deg	Gear Class
300	30	42	Commercial
550	120	150	Accurate
800	260	360	Precision

*Sum of gear and pinion values.

4. Ratio Factor, Q

Velocity Ratio, m_G	Q	Velocity Ratio, m_G	Q
1	1.00	4	1.60
2	1.33	5	1.66
3	1.50	10	1.82

solution gives D = 7.8 in. and d = 2.2 in.

Substituting $N_P = dP$ in Equation 4 gives

$$P = \frac{6.28\,d^2\,QK}{T\tan\psi\cos^2\psi}$$

$$= \frac{6.28(2.2)^2(1.56)(150)}{1050(\tan 23\text{deg})(\cos^2 23\text{deg})} = 18.8$$

Use P = 16, which gives $N_P = 16(2.2) = 35.2$. Use N_P = 35. Then, $N_G = 3.5(35) = 122.5$. Use N_G = 123. By simultaneous solution again, d = 2.1875 in. and D = 7.6875 in. Finally, from the relationships used to develop Equation 4, $f = 4\pi/(16 \tan 23 \text{ deg}) = 1.85$ in. Use f = 1⅞ in.

Bevel-Gear Relationships: Bending strength of bevel gears is given by:

$$f = ypfs\frac{A-f}{A} \tag{6}$$

Let $f = A/3$ (Fig. 2) and substituting

$$F = \frac{2TP}{N_P}$$

$$p = \frac{\pi}{P}$$

$$s = \frac{S}{K'} = \frac{S}{2}$$

$$A = \frac{d}{2\sin\gamma}$$

into Equation 6 gives

$$P = \left(\frac{0.0865\,N_P^2\,y\,S}{T\sin\gamma}\right)^{1/3} \tag{7}$$

The formula proposed by Buckingham[4] for wear strength of bevel gears is

$$F = 0.75\,d_{vp}\,f\,K\,Q \tag{8}$$

The factor of 0.75 accounts for the assumption that only about three-quarters of the full face of bevel gears is generally in effective contact. From Fig. 2, with $f = A/3$ and $d = N_P/P$, it can be shown that

$$f = \frac{N_P}{6P\sin\gamma}$$

$$d_{vp} = \frac{0.833\,N_P}{P\cos\gamma}$$

Substituting these expressions and $F = 2TP/N_P$ in

Equation 8,

$$P = \left(\frac{0.052\, N_P^3\, Q\, K}{T \sin\gamma \cos\gamma} \right)^{1/3} \quad (9)$$

Setting Equations 7 and 9 equal gives number of teeth N_P' on a bevel pinion with bending strength equal to wear strength:

$$N_P' = \frac{1.66\, y\, S \cos\gamma}{Q\, K} \quad (10)$$

Results of calculations for assumed values substituted in Equation 10 are given in Table 1. Here again, it appears that wear is the controlling factor in design for strength of most cut steel bevel gears.

Bevel Gear Design Example: Two 20-deg full-depth involute bevel gears are to transmit 40 hp at 900 rpm of the pinion. Power source is an electric motor operating 24 hr per day. Load is uniform. Speed ratio $m_G = 3$, and the gears are connected at a 90-deg shaft angle. If the pinion is to contain between 15 and 20 teeth and precision quality gears are used, determine their pitch and the specifications of the gear and pinion teeth.

Table 3—Application Factors

1. Duty Factor

Power Source	Duty Factor* Uniform Load	Moderate Shock Load	Heavy Shock Load
Electric motor	1.00	1.25	1.75
Multiple-cylinder engine	1.25	1.50	2.00
Single-cylinder engine	1.25	1.75	2.25

*Alter duty factors as follows, according to duration of operation: For 3 hr per day operation, multiply factor by 0.80; for 8 hr per day, multiply by 1.00; for 24 hr per day, multiply by 1.25.

2. Velocity Factor

Gear Class	Velocity Factor— Helical gears	Bevel gears
Commercial	1.83	2.50
Accurate	1.33	2.00
Precision	1.00	1.25

From Table 3, velocity factor = 1.25. Torque $T = 1.25(63{,}030)(40/900) = 4380$ lb-in.

From Table 2, ratio factor $Q = 1.5$. Also, for precision gears with $\phi = 20$ deg, load stress factor $K = 360$. Pinion pitch angle $\gamma = \arctan(300/900) = 18.5$ deg. Assume number of pinion teeth $N_P = 18$. From Equation 9,

$$P = \left[\frac{0.052(18)^3(1.5)(360)}{4380(\sin 18.5\ \text{deg})(\cos 18.5\ \text{deg})} \right]^{1/3} = 5.01$$

Use $P = 5$.

Therefore, pinion pitch diameter $d = 18/5 = 3.6$ in. and gear pitch diameter $D = 54/5 = 10.8$ in. Tooth face length is

$$f = \frac{1}{3}\left[\frac{(3.6)^2 + (10.8)^2}{4} \right]^{1/2} = 1.89 \text{ in.}$$

Use $f = 1\frac{7}{8}$ in.

Pinion pitch angle $\gamma = 18.5$ deg and gear pitch angle = 71.5 deg. Based on AGMA rating practices, these gears will transmit 30.5 hp safely. If diametral pitch P is decreased to 4, then $d = 4.5$ in., $D = 13.5$ in., $f = 2\frac{3}{8}$ in., and the AGMA durability rating is 49 hp.

Initial Design Data: Table 2 contains a collection of data to aid the designer in initiating a design with Equations 1 to 9. It is recommended that the value in these tables nearest to the actual design conditions be substituted into the proper equation for diametral pitch. For convenience, the many conditions of manufacture and finish for helical and bevel gears have been reduced to three general classifications of quality:

1. Commercial gears are defined as milled or generated gears made from cast iron, steel, or bronze and not heat treated.
2. Accurate gears are milled or generated gears made from steel and heat treated before cutting.
3. Precision gears are cut from steel, heat treated, and generation-grind finished.

After the pitch has been calculated, it should be rounded down to the nearest standard diametral pitch.

Load design factors are most conveniently applied by multiplying input torque by the factors and substituting this product for T in Equations 2, 4, 7, or 9. Table 3 lists typical values of conventional load factors and gives average values for pitch-line velocity factors. The latter data are sufficiently close for determining an initial diametral pitch.

REFERENCES

1. D. W. Dudley—*Practical Gear Design*, McGraw-Hill Book Co. Inc., New York, 1954, pp. 95-106.
2. D. J. Myatt—"Spur-Gear Design," MACHINE DESIGN, Vol. 30, No. 10, May 15, 1958, pp. 143-146.
3. E. Buckingham—*Analytical Mechanics of Gears*, McGraw-Hill Book Co. Inc., New York, 1949, p. 532.
4. Reference 3, pp. 540-541.

They Say . . .

"We can not measure the success of our scientific education by the number of satellites we produce. The true test of our scientific education is the elimination of scientific and mathematical illiterates. Sputniks are not enough. A citizenry informed in the fundamentals of contemporary history is what we need to sustain a free society."—JOHN RAY DUNNING, *dean, School of Engineering, Columbia University.*

DESIGN ABSTRACTS

electrical

Influence of High Operating Temperatures on Motor Design

R. S. Woll, Westinghouse Electric Corp.

A discussion of how high temperature affects motor operating characteristics, and how designers can choose effective insulation systems which will improve motor quality and reduce costs. A series of charts shows the influence of high operating temperatures under various conditions where motors with high-temperature insulation are likely to be applied. Effects of high temperatures caused by motor overloads, changes in ambient temperature, and types of motor conversion are covered. Virtues and limitations of high-temperature insulation are evaluated and their influence on motor design is discussed.

AIEE paper 58-1221, *prepared for the AIEE Fall General Meeting, Pittsburgh, October,* 1958; 3 *pp.*

Torque and Speed Control Of Induction Motors

J. F. Szablya, The University of British Columbia

Three basic schemes for the control of torque and speed of induction machines using saturable reactors. The paper discusses and evaluates the usefulness of the methods proposed. Methods presented here are not restricted to the use of saturable reactors, since any variable reactance provides the same results. However, the present stage of technical developments of the presaturated reactor favors its use for economy purposes.

AIEE paper 58-1320, *prepared for the AIEE Fall General Meeting, Pittsburgh, October,* 1958; 8 *pp.*

materials

Some Misconceptions In The Use of Stainless Steel

N. S. Mott, Cooper Alloy Corp.

How AISI wrought stainless steel designations are erroneously used in specifying stainless-steel castings. Composition ranges of the wrought steels, which have been developed to facilitate mechanical workings, frequently do not provide optimum properties for sound castings. ASTM designations A-296 and A-297 indicate stainless steel alloys for corrosion resistance and heat resistance respectively. Since cast ASTM designations are used for castings and wrought AISI designations for mechanically worked stainless steel, the comparable designations are listed and compared composition-wise. Evaluation of chemical compositions leads to the conclusion that the prevalent idea that presence of ferrite in all stainless steels is generally undesirable is a misconception. Presence of ferrite in moderate amounts in cast alloys leads to some important advantages.

CA Newscast, *Volume* 10, *No.* 5, *November,* 1958; *pp.* 2-3.

Fatigue and Aging

F. Bollenrath

A report of the reciprocal influence of aging and fatigue behavior for some aluminum alloys and a mild steel. Influence of vibrational strain on the course of aging is investigated. Mention is made of the interaction between rates of diffusion and strain, and the resonant frequencies corresponding to the temperatures present during vibrational strains are derived. The aging process is definitely influenced by oscillating plastic strain since heat is generated. Most structural materials are in an unstable state either initially or due to service conditions. These materials approach the equilibrium state of structure because of time and temperature changes.

NATO report 157, *Sixth Meeting of the Structures and Materials Panel;* 18 *pp.*

New Inorganic Insulation for 900 F Electrical Equipment

C. H. Vondracek and E. J. Croop, Westinghouse Electric Corp.

Electrical properties and application suggestions for a new, completely inorganic electrical insulation system. The insulation is effective after more than 500 hr of operation at temperatures to 900 F. Insulation is made from mica splittings sandwiched between layers of glass cloth and dipped in a solution of phosphate. The material is placed where required in the application and baked until it becomes hard and inflexible. Important features of the new insulation are: All inorganic insulating materials are prepared on conventional equipment, processing of the insulation into electrical equipment requires only minor changes from conventional methods, both sheet and wire insulation are flexible, and the material has satisfactory thermal stability for continuous operation to 900

F. The insulation is applicable to other electrical devices such as transformers, generators, solenoids, etc.

AIEE paper 58-1167, prepared for the AIEE Fall General Meeting, Pittsburgh, October, 1958; 8 pp.

Thermal Life of Enamel Magnet Wire

J. F. Dexter, Dow Corning Corp.

A presentation of data compiled by the AIEE Working Group on Thermal Stability of Insulating Materials. Temperature classifications, test procedures, and types of enameled magnet wire are covered. Most data were obtained on unvarnished and varnished test specimens of No. 18 and 20 AWG copper wire. A series of curves compares relative thermal life characteristics for unvarnished specimens and indicates the range of thermal stability among the various types of enamel.

AIEE paper 58-1205, prepared for the AIEE Fall General Meeting, Pittsburgh, October, 1958; 29 pp.

Creep-Rupture Strength of Austenitic Cr-Ni-Mo Steels

G. V. Smith, Cornell University, and F. Garofalo, R. W. Whitmore, and R. R. Burt, U. S. Steel Corp. Research Center

A comparison between creep-rupture strength of seven heats of bar stock and seven heats of sheet stock of austenitic Cr-Ni-Mo steels at 1100, 1300, and 1500 F. Bar-stock steels are slightly stronger at 1100, 1300, and 1500 F for rupture in 100 hr, and at 1300 and 1500 F for rupture in 1000 hr. At 1100 F no difference is found between bar and sheet steels for the 1000-hr rupture strength.

ASME paper 58-A-102, ASME Annual Meeting, New York, December, 1958; 7 pp.

Structural Adhesives For Air Vehicles

D. L. Grimes

Application of adhesives as structural-joint media for aircraft and missiles. A systematic and detailed discussion is included of the advantages and disadvantages of adhesives. Major reasons for designing for adhesive bonding include weight savings, improved fatigue strength, improved structural and acoustical properties, manufacturing economies, improved thermal insulation, and corrosion control. These advantages are investigated in detail. Actual application examples are used to clarify the major problems that each advantage has overcome.

NATO report 181, Seventh Meeting of the Structures and Materials Panel, 1958; 28 pp.

High-Temperature Elastomers

E. R. Bartholomew

A review of the source and nature of high-temperature elastomer problems and the limitations of the more conventional elastomer materials. Materials investigated include natural rubber, synthetic elastomers, butyl rubber, silicone-base elastomers, butadiene-acrylonitrile copolymers, and fluoro-elastomers. Physical, chemical, and mechanical properties of the various formulations are included.

NATO report 178, Seventh Meeting of the Structures and Materials Panel, 1958; 23 pp.

techniques

How to Specify Noise Ratings Of Electric Rotating Machines

M. E. Talaat, Elliott Co.

A guide to establishing the noise rating of an electric rotating machine which satisfies requirements of a certain acoustic criterion at any given point in the noise field of the machine. The simple method allows one to proceed from the definite-risk criterion to the specification of the noise rating of the machine in terms of octave-band power levels. A simple relationship based on noise analysis tests on various machines helps correlate the new noise rating in terms of power level and the old noise rating in terms of pressure level.

AIEE paper 58-1179, prepared for the AIEE Fall General Meeting, Pittsburgh, October, 1958; 16 pp.

Nonmechanical Machining Methods

L. A. Williams, Anocut Engineering Co.

A discussion of machining by spark-arc disintegration, chemical milling, and electrolytic methods as applied to new metals. A comparison of these methods is made with other conventional machining processes. Problems of conventional machining methods are analyzed, and recommendations made for overcoming these problems with the newer machining methods. When, where, and how to use these methods are discussed.

ASTE paper 140, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 9 pp.

Machining and Fabricating High-Strength Steels

P. S. Kikeli and F. Farago, The Cleveland Pneumatic Tool Co.

Some problems of new manufacturing techniques and their influence on design practices. Problems of design pertinent to forging operations, contour machining, work holding fixtures, and drilling and boring of hollow parts are discussed.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 41-51.

Methods of Joining High-Temperature Alloys

J. C. Herr, General Dynamics Corp.

Methods of joining and joint efficiencies of stainless steel, titanium, magnesium, and aluminum alloys. Relative merits of welding and mechanical fastening of these alloys are discussed and inspection practices of joints are recommended.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 69-74.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

CA Newscast—Cooper Alloy Corp., Hillside, N. J.

NATO—National Aeronautics and Space Agency, 1512 H St., N. W., Washington 25, D. C.

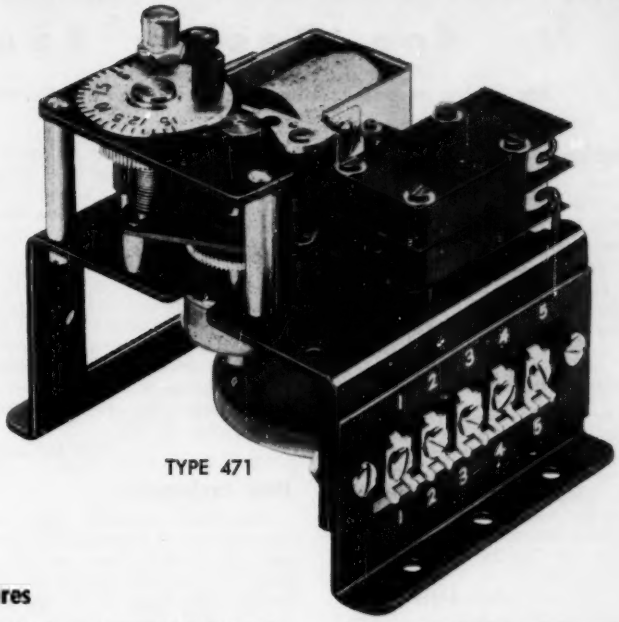
ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

ASTE—American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

ASM—American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

New adjustable time delay relay provides wide selection of time ranges

The new Cramer Type 471 Time Delay Relay provides an accurate, adjustable time delay between the operation of a control circuit and the subsequent closing or opening of one or two load circuits. Through selection of external wiring connections, the unit offers broad application flexibility and excellent accuracy at modest cost. Some typical uses include control of machine tools, batch processes, heat treating, automatic mixers, electronic devices, and signalling equipment of many kinds.



TYPE 471

Operation

Type 471 is powered by a Cramer synchronous motor which drives precision-cut timing cams through a clutch, from a starting point set by a dial knob. The cams rotate at constant speed to a zero point, where the load switch is transferred. An instant later, a second cam opens the motor circuit. The clutch stays engaged, and the unit does not reset until the operator either opens the clutch circuit for the direct-clutch model, or closes the clutch circuit for the reverse-clutch model.

The direct-clutch unit resets automatically on power interruption, and repeats its complete cycle when power is restored. The reverse-clutch unit simply suspends operation and, when power returns, proceeds to complete the same time interval. Resetting is accomplished by a coil spring which drives the cam carriage back to a movable stop which is positioned by the dial knob. The stop location determines how quickly the cams will reach the switch actuation points, and so determines the timed interval.

Features

TIME RANGES — 15 seconds to 24 hours.

ADJUSTMENT RANGE — 90% of full scale.

ACCURACY — within 2% of full scale.

RESET TIME — approx. ⅓ second or less.

LOAD SWITCHES — snap-acting SPDT, 10A 125V or 5A 250V AC, non-inductive.

MOTOR & CLUTCH — 115/220V, 25, 50 and 60 cycles. Reverse clutch optional.

GEARS — case-hardened steel, for life in excess of a million operations.

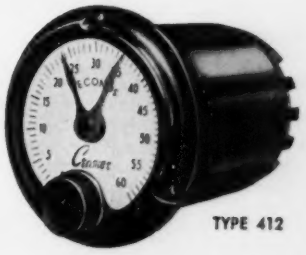
For details, write for your free copy of Bulletin PB-471.

TIME RANGES AND MINIMUM SETTINGS

TIME RANGE	DIAL DIVISIONS	MINIMUM SETTING
15 sec.	½ sec.	1.5 sec.
30 sec.	1 sec.	3 sec.
60 sec.	2 sec.	6 sec.
5 min.	10 sec.	30 sec.
15 min.	30 sec.	1.5 min.
30 min.	1 min.	3 min.
60 min.	2 min.	6 min.
2 hrs.	5 min.	12 min.
5 hrs.	15 min.	36 min.
12 hrs.	30 min.	1¼ hrs.
24 hrs.	1 hr.	2½ hrs.

FOR EXTREME ACCURACY PLUS WIDE SELECTION OF RANGES

Type 412 performs essentially the same functions as Type 471, except that it is designed for panel mounting, extreme accuracy, heavier loads, and 100% adjustability over the entire time range of each unit. Eleven full-scale time ranges are available, from 6 seconds to 24 hours. Overall accuracy is within plus or minus ½ of 1% of full scale, exclusive of setting errors. Repeat accuracy is within plus or minus ¼ of 1% of full scale on 30 second and longer ranges, and ½ of 1% of full scale on faster timers. The fully enclosed dial carries a red pointer to indicate the setting, a black pointer to indicate timing progress. The open blade SPDT load switch is rated 15A 125V, 10A 250V AC, and can handle inrush currents up to 40 amperes. A second load, operating within 1% of full-scale time following the first load. can be controlled from the motor switch itself. Internal SPST seal-in contacts permit operation from a 1/10-sec. control pulse if desired. Direct or reverse clutch operation is as described for Type 471.



TYPE 412

CRAMER CONTROLS

CORPORATION

Box 6, Centerbrook, Connecticut

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Gas Turbines

Operating experience with the Mark TA 750/1000 kw gas turbine is detailed in Bulletin 167. Design features, types of fuels, and applications in oil fields and process industries are discussed. Assessment is also made of the integrated turbine-boiler package. 16. pages. Clark Bros. Co., Olean, N. Y. N

Circle 601 on Page 19

Electromagnetic Bin Vibrators

Line of electromagnetic vibrators descriptively covered in latest catalog includes models for vibrating less than 1 cu ft on up to those capable of vibrating bins, hoppers, and bunkers containing materials weighing in excess of 150 tons. Typical installations are shown. 12 pages. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 602 on Page 19

Aircraft Ducting Products

Series of technical bulletins dealing with aircraft ducting products covers tolerance take-up units for ducting systems, resilient seals, bellows-duct components, and Arcosil 27, a flexible ducting for tubing, sleeves, and couplings. 2 and 4 pages. Federal-Mogul-Bower Bearings, Inc., Arrowhead Products Div., 2300 Curry St., Long Beach, Calif. L

Circle 603 on Page 19

Valve Flanges

Information on Janitrol, Marman, thread, bead, bolt, and special type flanges for air valves is provided in Bulletin F 8517 to help in flange selection. Drawings show complete dimensions. Barber-Colman Co., Aircraft Controls Div., Rockford, Ill. K

Circle 604 on Page 19

Temperature Control

Model RVA recording pneumatic temperature control described in Bulletin 242 is available in any of 10 optional temperature ranges between −30 and 1100° F. Operation, features, accessories, and ordering instructions are reviewed in the folder. 4 pages. Partlow Corp., New Hartford, N. Y. D

Circle 605 on Page 19

Steel & Aluminum

Data book includes aluminum analyses, characteristics, mechanical properties, and tolerances, plus previously published information on steel, such as machining and fabricating data, manufacturing practices and tolerances, weights, safe loads, ASTM standards, compositions, and properties. An extensive section on definitions is included, along with much general information. 256 pages. Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill. I

Circle 606 on Page 19

Circuit Breakers

Aid in the selection of molded case circuit breakers and enclosures is provided by illustrated pocket-size Bulletin 5004-1A. Master selection chart groups breakers by types and current ratings. Specifications of each are given. 8 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa. C

Circle 607 on Page 19

Heat Exchangers

Dimensions, capacities, and operating characteristics of Impervite Cross-Bore impervious graphite heat exchangers are found in illustrated Bulletin 660. Standard models have from 21 to 470 sq ft of heat transfer surface. General dimensions are given. 8 pages. Falls Industries, Inc., Aurora Road, Solon, Ohio. F

Circle 608 on Page 19

Thermostats

Complete line of Stemco bimetal thermostats for use in appliances, apparatus, electronic, and avionic applications is detailed in Bulletin 8400. Operating ranges, electrical ratings, mounting, enclosures, etc., are given in condensed form. 4 pages. Stevens Mfg. Co., Box 1007, Mansfield, Ohio. G

Circle 609 on Page 19

Flowmeter

Model A5Y 2-in. industrial liquid flowmeter which uses the Vortex Velocity principle is subject of Catalog Sheet CM-10. The stainless steel unit is rated at 20 to 220 gpm for 1500-psi working pressure. General data and specifications are included. 4 pages. Rotron Controls Corp., Woodstock, N. Y. D

Circle 610 on Page 19

Submersible Motors

Illustrated Bulletin GEA-6883 describes submersible wet winding motors designed to run under water, even with insulation and bearings immersed. Motors utilize irradiated polyethylene insulation and are rated from 100 to 500 hp. Cutaway diagram, rating chart, and dimensions are provided. 2 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 611 on Page 19

Transistors

Type 2N1005 and 2N1006 n-p-n grown diffused silicon transistors for high speed switching applications are detailed on Data Sheet DL-S 968. Bulletin DL-S 970 presents data on Type 2N1048, 2N1049, and 2N1050 n-p-n diffused junction silicon transistors. Characteristics and mechanical data are included. 2 and 1 pages. Texas Instruments Inc., Box 312, Dallas, Tex. P

Circle 612 on Page 19

Solenoid Valve

Two and three-way high pressure solenoid valves for hydraulic power systems are described and illustrated in Catalog 2000. Both alternating and direct current models are covered. Units rated at 3000 psi have port sizes from ¼ to ¾ in. 12 pages. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill. J

Circle 613 on Page 19

Carbon-Graphite

Karak carbon-graphite for electrical, mechanical, thermal, and chemical applications is described and some of its uses shown in Bulletin 1164A. Characteristics, applications, design data, and properties of the various grades are covered. 8 pages. Ohio Carbon Co., 12508 Berea Rd., Cleveland 11, Ohio. G

Circle 614 on Page 19

Steel Bars

Improvements in high strength, free-machining Stressproof steel bars are highlighted in bulletin. Results are better strength, machinability, and tolerances. Properties are given. 4 pages. La Salle Steel Co., Box 6800-A, Chicago 80, Ill. J

Circle 615 on Page 19

Flexible Teflon Hose

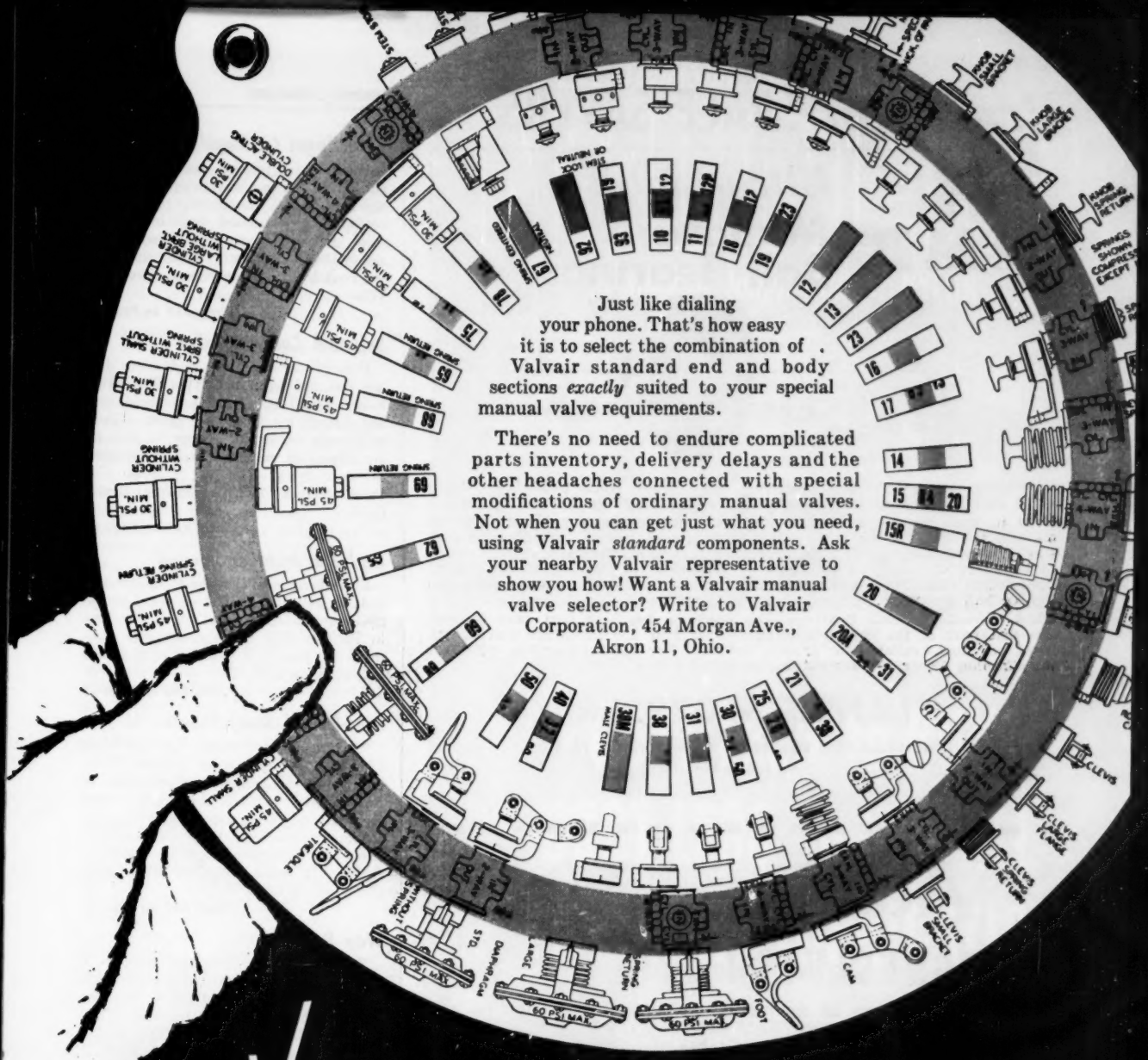
Zero-Motion steel braiding process, and improved means of assembly and attachment are described in Bulletin 400 on Springfield 400 Finger-Flexible Teflon hose for industrial and aircraft uses. Specifications are given, along with other data on the convoluted product. 6 pages. Titeflex, Inc., Hendee Street, Springfield, Mass. B

Circle 616 on Page 19

Gearing

Facilities of this company for gear blanking, gear cutting, gear train, and subassemblies are explained in illustrated bulletin. Included is a useful table on the 20-degree involute fine-pitch system which gives all pertinent dimensions for 20 to 120 diametral pitch gears. 4 pages. Juall Gear Co., 1108 Goffle Rd., Hawthorne, N. J. D

Circle 617 on Page 19



Just like dialing your phone. That's how easy it is to select the combination of Valvair standard end and body sections *exactly* suited to your special manual valve requirements.

There's no need to endure complicated parts inventory, delivery delays and the other headaches connected with special modifications of ordinary manual valves. Not when you can get just what you need, using Valvair *standard* components. Ask your nearby Valvair representative to show you how! Want a Valvair manual valve selector? Write to Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio.

Valvair *manual valves*

. . . unlimited combinations using standard components!

Find us fast in the 'Yellow Pages'

Compare . . . and you'll buy

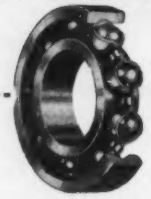
Valvair

SALES AND SERVICE FROM LOCAL STOCK

Representatives in principal cities throughout the world

Precision SPACE SAVERS

RMB *Ultra-Light* Miniature Ball Bearings



UL Series
12 Sizes from 0.1181" OD
0.0394" Bore to 0.7480"
OD 0.3937" Bore

Combining small OD's with relatively large bores, RMB Ultra-Light Miniature Ball Bearings offer the designer precision bearings that save on space. Used in such devices as instrument gear trains, gyroscopes, and synchro motors, bearings in the RMB Ultra-Light Series are of Conrad type construction with deep groove, uninterrupted raceways. They are manufactured to boundary dimensions established by Anti-Friction Bearing Manufacturers Association (AFBMA), and all but the two smallest sizes feature a balanced 2-piece ball separator.

RMB Ultra-Light Ball Bearings—the precision bearings that save space—are just part of the complete RMB line of over 250 miniature and instrument bearings available for prompt delivery. For full information, write for our Catalog 50, or see our catalog in Sweet's files.

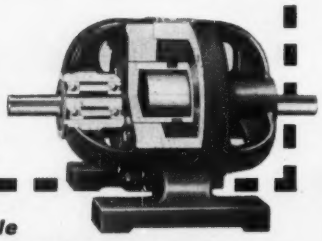
LANDIS & GYR, Inc.

45 West 45th Street • New York 36, N. Y.

Circle 480 on Page 19

VICKERS®

MAGNECLUTCH™



The most versatile and dependable clutch for power transmission and torque control . . . MAGNECLUTCHES lick the toughest application problems

The Vickers MAGNECLUTCH consists fundamentally of two rotating concentric cylinders coupled by dry magnetic particles under the influence of a magnetic field. With no direct contact between clutching surfaces, there is no wear; life of the MAGNECLUTCH is exceedingly long. Torque is easily regulated by varying the magnetizing coil current.

Unlike all other industrial clutches, torque transmitted is independent of speed. Since starting and running torques are the same, there is no grab or chatter during acceleration or braking periods; operation is extremely smooth. Torque is transmitted at zero slip with 100% mechanical efficiency. MAGNECLUTCHES have a broad range of operating speeds, provide torque limiting, fast response, and can be easily and remotely controlled.

The many unique features of MAGNECLUTCHES make them the most versatile and dependable clutches available, whether for tension control, cycling (start-stop) operation, torque limiting, controlled acceleration, wind-up, starting of high inertial loads, or constant torque transmission. ***Write for Bulletin 6000A***

ELECTRIC PRODUCTS DIVISION — VICKERS

Sales Engineering Offices: Boston • Chicago • Cleveland Detroit • New York • Washington, D. C. • Los Angeles

VICKERS INCORPORATED EPA 6100-1

DIVISION OF SPERRY RAND CORPORATION

ELECTRIC PRODUCTS DIVISION

1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

Centrifugal Castings

Facilities for melting and casting, machining, inspection, and shipping stainless and alloy steel centrifugal castings are outlined in illustrated bulletin. Technical data on most widely used alloys are presented. 4 pages. Wisconsin Stainless Foundry & Machine Corp., Waukesha, Wis. K

Circle 618 on Page 19

Solenoid Control Valve

Principle of operation and other data are included in Bulletin B-136 on 1 to 4-in. screwed and flanged solenoid control valves for fluids or gases. Globe and angle valves for service to 160 psi are offered in energized and de-energized to open styles. 4 pages. Cla-Val Co., Seventeenth & Placentia, Newport Beach, Calif. L

Circle 619 on Page 19

Explosionproof Equipment

Everything from lighting to motor controls as well as Condulet electrical equipment for hazardous locations is described in Bulletin 2710 on explosionproof electrical equipment. 6 pages. Crouse-Hinds Co., Syracuse 1, N. Y. N

Circle 620 on Page 19

Zinc-Plated Steel Sheets

"Electro Paintlok Sheets Take and Hold Paint Better" is title of Bulletin 655R. It explains advantages and properties of this material which is chemically treated to take and hold paints, lacquer, synthetics, and enamels. Properties, available sizes, and application suggestions are included. 12 pages. Republic Steel Corp., Cleveland 1, Ohio. F

Circle 621 on Page 19

Way Bearings

Tychoway way bearings employ a unique system of recirculating antifriction rollers to give unlimited travel, constant accuracy, and minimum friction. They are available for loads from 2000 to 32,000 lb. Details are given in Form 2. 4 pages. Tycho Mfg. Co., 561 Hillgrove Ave., La Grange, Ill. I

Circle 622 on Page 19

Electric Pushbuttons

Single element, standard duty type, electric pushbuttons with double-break contacts and with stop, start, for, rev, or jog, markings as well as blanks are described in Bulletin 2901. 1 page. Ward Leonard Electric Co., Mount Vernon, N. Y. D

Circle 623 on Page 19

Compression Packings

Handy 17½ x 9-in. chart for hanging on wall or storage bin gives recommendations for the selection and proper application of Val-Pac rod and sheet type packings. Types are shown for eight basic services, including air and inert gases, water and neutral fluids, acids and alkalies. 1 page. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 624 on Page 19

Circle 481 on Page 19

Aircraft Locknut

Weight savings up to 72 per cent over conventional types are possible with Featherweight locknuts detailed in Bulletin 2426. Designed for missile and aircraft applications, these fasteners have tensile strength in excess of 125,000 psi. Tables compare weights with other locknuts in sizes from No. 4-40 to 3/8-24. 4 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 625 on Page 19

Spraying Systems

Industrial spray nozzles and related equipment are detailed in Catalog 24. Capacities range from 1 oz per hr to over 4000 gpm. Nozzles are made in a wide range of materials for specific service or fluid conditions, and with practically any conceivable spray pattern. Technical design section includes tables on spray coverage, pipe friction, and related information. 52 pages. Spraying Systems Co., 3274 Randolph St., Bellwood, Ill. I

Circle 626 on Page 19

Air Control Equipment

Air regulators, filters, lubricators, drain traps, dehumidifiers, and combinations for use in compressed air lines serving all types of tools and equipment are subject of illustrated Bulletin 80. 12 pages. Perfecting Service Co., 332 Atando Ave., Charlotte 6, N. C. A

Circle 627 on Page 19

Valve Operated Cylinder

Bulletin 91008 furnishes data on parts and operation of the V.C. Series valve and cylinder combination offered in 1, 1 1/8, and 1 1/2 in. bore sizes for up to 200-psi air, water, and oil service. The combination will withstand a minimum of 20 million operating cycles. 6 pages. Airmatic Valve, Inc., 7313 Associate Ave., Cleveland 9, Ohio. G

Circle 628 on Page 19

Retaining Rings

Included in Catalog RR 10-58 are selector guides to 20 standard ring series and 30 representative special rings designed for specific requirements. Standard Waldes Truarc retaining rings are available in diameters from 0.04 to 10 in. and in six metal specifications and 13 different finishes. Details of available types and their applications are discussed. Assembling tools, applicators, and dispensers are described. 24 pages. Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N. Y. C

Circle 629 on Page 19

Potentiometers

Key information on Trimpot and Trimit lead screw actuated potentiometers is summarized in quick-reference Specification Summary No. 4. A spec table lists resistances, terminal types, end settings, power ratings, operating temperatures, and dimensions. 4 pages. Bourns Laboratories, Inc., Riverside, Calif. L

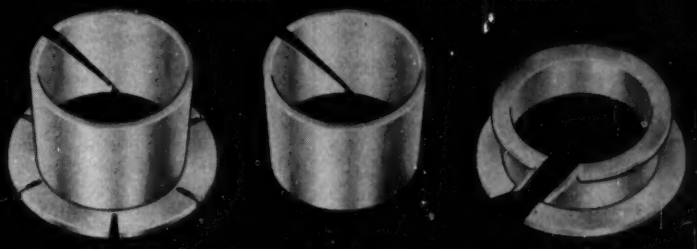
Circle 630 on Page 19

Circle 482 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS

of smooth, tough DuPont NYLON



Low Cost FLANGED Nyliner

Low Cost SLEEVE Nyliner

Low Cost DOUBLE-FLANGE Nyliner

BETTER BEARINGS THAT...

• COST LESS to BUY*

• COST LESS to INSTALL

& ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

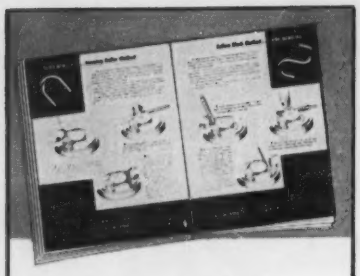
Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

*In production quantities at new, REDUCED PRICES.

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

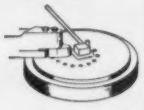
Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

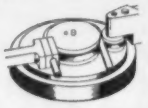


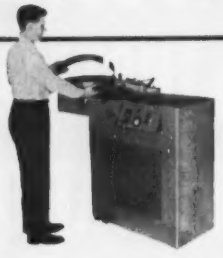
How to form it by

BENDING...

Free Manual shows techniques of forming round, square, or hex bar stock... tubing...channel... angle... flat and other materials.







Di-Acro Hydra Power Bender

It's easy to bend a wide variety of material when you know how—profitable too because bending can simplify product design—make one curved piece do the job of two or more. Bending can improve product appearance and lower your production costs!

This 32-page illustrated manual shows how to make center eye and off center bends, circles, zero radius bends, scrolls, squares, springs and coils, loops and spirals—all with *one versatile machine.* Booklet also tells how to tool for tubular, channel, angles and other special bending needs.

Order your free copy today. Consult the yellow pages of your phone book under Machinery—Machine Tools for the name of your nearest Di-Acro distributor or write us.

di-acro PRECISION METALWORKING MACHINES

Find Us Fast In The Yellow Pages

pronounced die-ack-ro

O'NEIL-IRWIN MFG. CO.
416 8th Avenue, Lake City, Minnesota

Circle 483 on Page 19

HELPFUL LITERATURE

Servo Components

Bulletins 36100, 36200, 36300, and 36400 contain design, performance, and application data on Electrohydraulic servo valves, power amplifiers, preset and manual units, and panels for use with this equipment. Designed for industrial fluid power systems, this new Servocontrol equipment is extremely flexible in its application. 8, 4, 4, and 4 pages, respectively. Oilgear Co., 1560 W. Pierce St., Milwaukee 4, Wis. K

Circle 631 on Page 19

Industrial Controls

Among the electric, electronic, and pneumatic industrial controls described in Catalog C 101-1a are temperature, pressure, and humidity controls; pneumatic motors; Actionators; dampers; pneumatic relays; electric relays; and pneumatic switches. The 7-page front section deals with applications for industrial controls. 84 pages. Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Avenues, Philadelphia 44, Pa. E

Circle 632 on Page 19

Precision Components

Detailed specifications and performance data are provided in folder on cams, synchros, mechanical differentials, Oldham couplings, and 10-w low-inertial servo motors for use in computers, instruments, and control systems. 4 pages. Ford Instrument Co., 31-10 Thomson Ave., Long Island City 1, N. Y. D

Circle 633 on Page 19

Hastelloy Alloys

Devoted to fabrication of Hastelloy alloys, Booklet F-30,126 covers step-by-step procedures and recommendations for welding, forging, forming, machining, grinding, brazing, heat-treating, and descaling and pickling. Lining of vessels and corrosion surfacing is also included. 36 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 634 on Page 19

Air & Gas Filters

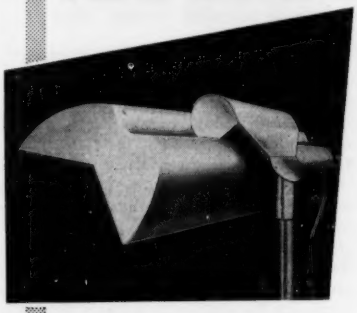
Line of Fulflo filters for compressed air and gases described in Bulletin GEO-507 includes several single tube models for operating pressures from below 125 up to 4000 psi and flow rates as high as 800 scfm. Technical data include flow characteristics and dimensions. 4 pages. Commercial Filters Corp., 2 Main St., Melrose, Mass. B

Circle 635 on Page 19

Bearings, Bushings & Parts

Details on Graphex, Coprex, and Woodex oilless and self-lubricating bearings, bushings, and machine parts are content of illustrated catalog. Properties of powdered metal compositions, tables of standard sizes, micrographs of metal structures, bibliography of powder metallurgy articles, and information on sintered metal parts are included. 72 pages. Request on company letterhead from Wakefield Bearing Corp., 29 Foundry St., Wakefield, Mass. B

Another product made better with MOLDED FIBER GLASS



It's a street light housing

for the new Westinghouse Mainstreeter Fluorescent Luminare

. . . weather resistant, won't rust, rot or corrode

. . . tough, resistant to hail, wind, mechanical damage

. . . lightweight, rigid, easy to mount

. . . molded-in color requires no painting

. . . smooth, modern, streamlined — custom molded to Westinghouse designs

. . . and economical!

Do you have a product which can be made *better,* at less cost, with MOLDED FIBER GLASS? Write today. Free literature available.

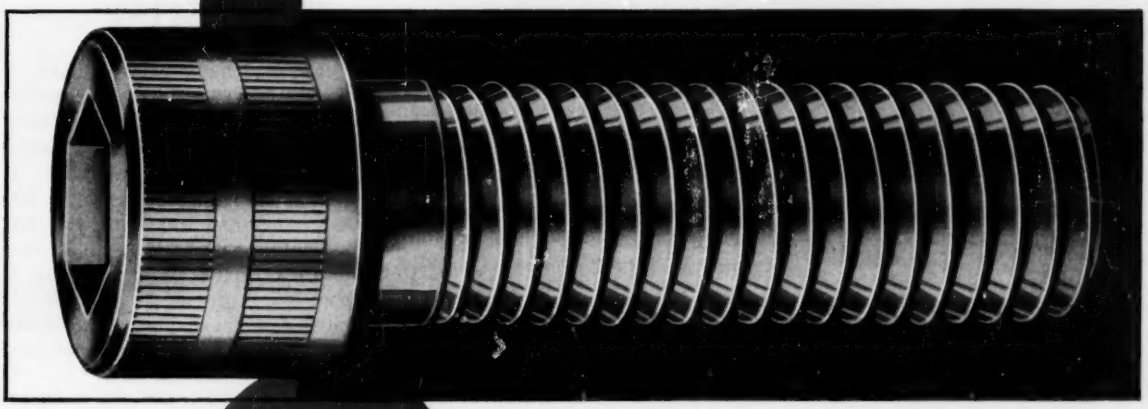
Molded Fiber Glass Company

GREATEST NAME MOLDED FIBER GLASS IN REINFORCED PLASTICS

4429 Benefit Avenue, Ashtabula, Ohio

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Problem: *"Weight is serious problem . . . fewer fasteners the better. If possible, three fasteners should do the work of four. Surface must be flush to give a smooth, streamlined appearance to the product. Only a limited wrenching space is available . . ."*



Solution: *HOLO-KROME SOCKET HEAD CAP SCREWS. Made of special analysis alloy steel heat-treated to 38-42 Rockwell "C" hardness. Sockets are scientifically proportioned for highest strength. Internal hex socket drive assures a smooth, unmarred head. New forging method results in improved fiber flow, tougher screws. Threads are Unified Class 3A fit.*

For the finest in Hex Socket Screws . . . for unmatched Same-Day Service, the name to remember is Holo-Krome.

HOLO-KROME
SOCKET SCREWS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Tiny Mufflers

are compact, durable, and economical

Long-lasting polyether foam, enclosed in anodized aluminum shell, provides silencer for noises caused by exhausting air. Three models are low in price and small in size. Model M-1 (top) mounted flush to a ⅛ or ¼-in. exhaust port pro-

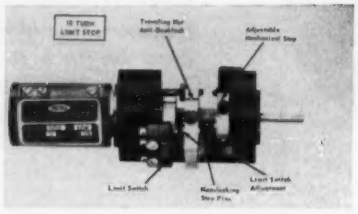
trudes only ¾ in. Model M-2 (left) is only 1 in. long and also accommodates ⅛ or ¼-in. exhaust ports. Larger size, M-3 (right), is 1¾ in. long and fits into a ⅜-in. port. Mufflers are rustproof throughout and can be cleaned in most common solvents. **Mead Specialties Co.**, Dept. MM-25, 4114 N. Knox Ave., Chicago 41, Ill. J

Circle 636 on Page 19

Miniature Limit Stop

incorporates nonlocking mechanical stops

Redesigned miniature limit stop, designated P/N 9501, provides open housing with improved accessibility to switch adjustment. Radial loading pin-stops are used to provide nonlocking mechanical stops which can be adjusted to any position or any number of turns from 10 to 0. Traveling nut provides antibacklash features which permit more accurate actuation of limit switches. Standard configura-



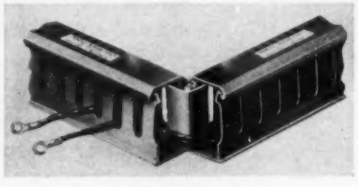
tion, intended for a ten-turn potentiometer, provides maximum of ten turns and is adjustable to any lesser number. Electrical limits can be set easily within 5 deg and repeat within 2 deg. Special designs are available for larger number of turns, and with energy absorption at both ends. Weight of standard unit is 4 oz. **United Hydraulics Inc.**, 110 Terrell Court, Dayton 7, Ohio. G

Circle 637 on Page 19

Right-Angle Strip

provides rounded corners for plastic wiring duct

Corner-Strip facilitates plastic wiring duct installation and provides smooth, rounded corners at all duct junctions. It is a plastic right-angle piece, slotted at each side of angle bend to receive side walls of connecting duct sections. Slots incorporate an overlapping leg design which allows quick, easy attachment yet grips duct firmly and securely. Strip is high-temperature polyvinyl-chloride plastic which is nonflammable, flexible, tough, and durable. Unit is furnished in 5-ft lengths and is easily cut to correspond to duct height. Corners for any of 19 sizes and three types of



wiring duct can be fabricated from one style of Corner-Strip. **Panduit Corp.**, Dept. MDC, 14461 Waverly Ave., Midlothian, Ill. J

Circle 638 on Page 19

Heat-Resistant Paint

withstands temperatures to 1700 F

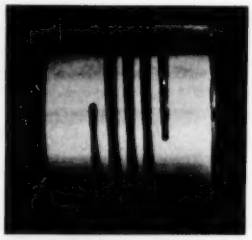
Heat-Rem H-170 paint is made of heat-resistant aluminum, combining both leafing and nonleafing characteristics, and colored metallic pigments in a silicone base. It withstands temperatures from 200 to 1700 F, and fuses with hot surfaces to form a continuous, uniform, attractive coating. Paint is available in aluminum, metallic blue, metallic red, and gold. **Speco Inc.**, 7308 Associate Ave., Cleveland 9, Ohio. G

Circle 639 on Page 19

Miniature Shaft Couplings

¼-in. long units weigh 1/30 oz

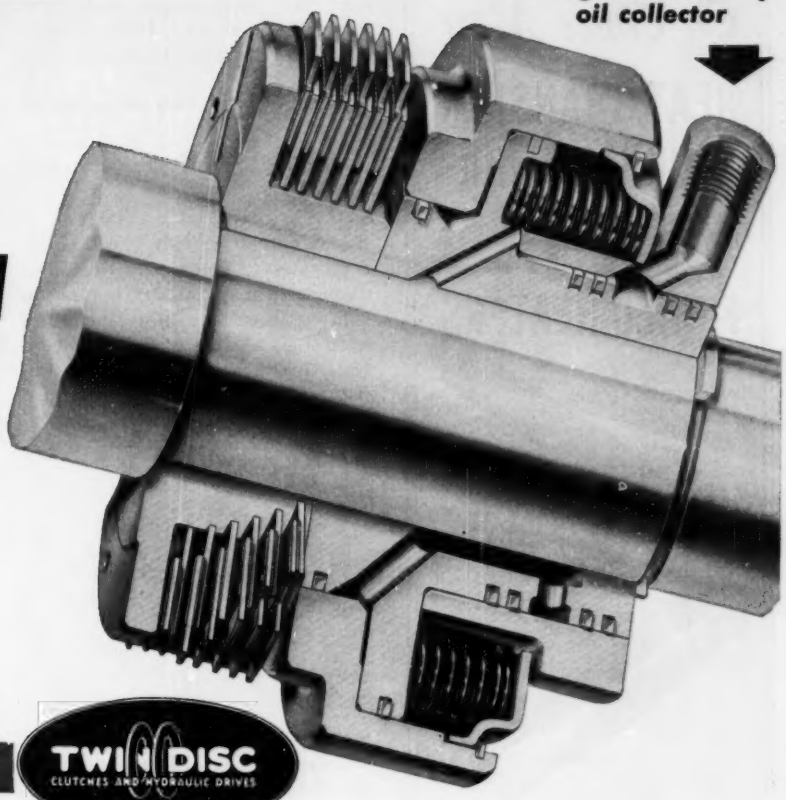
Shaft couplings provide smooth bearing loads, constant velocity, and absolute zero backlash. Units



for ⅛-in. shaft have diameter of ¼ in., length of ¼ in., and weight of 1/30 oz. Each coupling is ground from a solid piece of material, eliminating solder joints, pins, screws, or rivets. Integral flanges, gears, clutch and brake components, and/or shafts can be incorporated in couplings made from creep-resistant material such as stainless

NEW Twin Disc Oil-Actuated Multiple-Plate Clutches

Now available with integral stationary oil collector

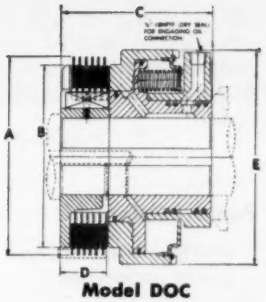


TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

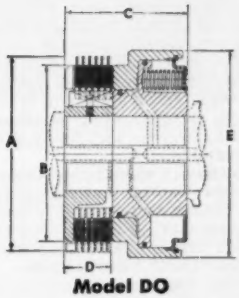
Clutch failures and burn-outs are virtually eliminated in these new wet-type Twin Disc Clutches. No adjustments are needed because ram travel compensates *automatically* for plate wear.

Designed for machine tools and similar applications, these units are built to run in oil and are actuated by oil pressure of 100 to 300 psi. Model DOC (shown above) has an around-the-shaft oil collector connected by a ¼" line. Model DO is identical except that the oil collector is omitted, shortening the clutch somewhat.

Compact design, smooth performance, long wear—with no adjustment problems—these benefits are available *now* in Twin Disc Oil-Actuated Multiple-Plate Clutches. Write for Bulletin 314.



Model DOC



Model DO

Model No.	Torque Capacity Lb.-ft.	Hp Capacity	Max. Allowable Rpm		A	B	C (length)	D	E
			With Hydraulic Balance	Without Hydraulic Balance					
DO-403	37	9	5000	2700	3.31	3.00	2.580—2.566	1.02	3.80
DOC-403			5000	3480			3.500—3.486		
DO-403½	95	20	5000	2680	3.81	3.50	2.892—2.872	1.17	4.42
DOC-403½			5000	3500			3.780—3.766		
DO-604	130	31	5000	2670	4.38	4.00	3.255—3.241	1.26	4.80
DOC-604			5000	3660			4.160—4.142		
DO-605	330	58	4500	2270	5.50	5.00	3.447—3.429	1.35	5.90
DOC-605			4500	3070			4.267—4.249		
DO-706	435	100	3750	1815	6.56	6.00	3.981—3.963	1.60	6.90
DOC-706			3750	2560			4.822—4.804		
DO-707	690	137	3250	1790	7.62	7.00	4.697—4.679	2.12	8.00
DOC-707			3250	2550			5.540—5.522		

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • LOS ANGELES • NEWARK • NEW ORLEANS

Circle 485 on Page 19

6 Times More

HEAT TRANSFER SURFACE with VULCAN FINNED HEATERS

You get *six times more* effective heat transfer surface with Vulcan Finned Strip or Tubular Electric Heating Elements than with conventional strip or tubular heaters. They provide ideal heat for blower type electric unit heaters; duct heating; unit convection heating; as oven or space heaters in dryers, pumps, rooms, etc.; baseboard room heaters — and many other applications.

You have a wide choice of standard sizes; wattage and voltage ratings; sheath metals; and terminal construction. Finned Tubular heaters are available in straight lengths or with hairpin bends.

When you have *unusual* specifications, solve your hot problems with *Vulcan Versatility* in the application of electric heat. Send coupon for catalog.

VULCAN ELECTRIC COMPANY Danvers, Mass.

VULCAN ELECTRIC COMPANY, Danvers, Mass.
Please send me your catalog and price information on Vulcan Finned Strip and Tubular Heating Elements.

Name & Title.....

Company.....

Street & No.....

City & State.....

Circle 486 on Page 19

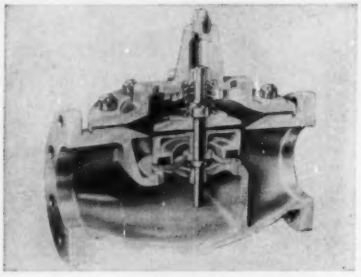
steel, beryllium copper, and high-temperature alloys. **Helical Products Co.**, 1402 The Strand, Hermosa Beach, Calif. L

Circle 640 on Page 19

Hydraulic Valve

for high-temperature use

Avsco automatic valve, which incorporates a new heat-resistant diaphragm material, can be used in continuous service at temperatures to 250 F. Valve is a remote-control, hydraulically actuated unit with backless design. Disc which opens and closes valve is an integral part of diaphragm assembly. Maintenance is reduced since no lubrication or packing are required. Valve is closed by hydraulic pressure applied to valve cover through small control tube. Unit is available in sizes from ½ to 16 in. with screwed or flanged connections. **Automatic Valve Systems Co.**, 1535 Monrovia Ave., Newport Beach, Calif. L



Circle 641 on Page 19

Panel Receptacle

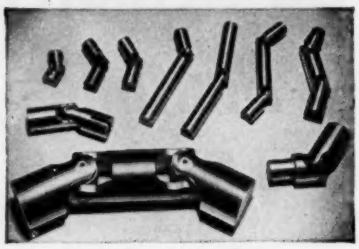
provides fast, low-cost power connection

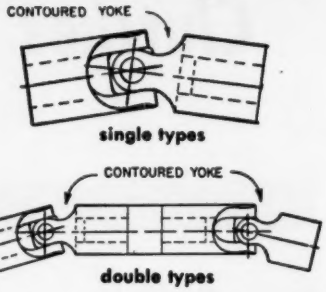
Fully insulated high-impact plastic panel receptacle is self-contained and self-insulated. It can be mounted directly on electrical distribution cubicles, switchgear, junction boxes, bus duct, wireway, or any electrical panel, to produce an economical dead-front power connection. Plastic insulation assures shockproof panel mounting and prevents short circuiting of power-distribution equipment. Receptacle, with mating plug, affords a rapid means for connecting and disconnecting power cables. Connection withstands pulling force of 1000 lb. Receptacles and plugs ac-

Lovejoy

UNIVERSAL JOINTS

INDUSTRY'S MOST COMPLETE LINE FOR EVERY SLOW SPEED APPLICATION





Check these features against your requirements:

Special Contoured Yoke—capable of operating at a maximum angular misalignment of 45° on hand-operated applications.

Static Torque—from 306 to 129,693 in.-lbs. at 12°, depending on size of joint.

Horsepower Ratings—.54 to 207 at 100 rpm.

Tolerances—pins ground to .0005" ...forks concentric to within .001" ...precision accurate center blocks.

Standard Specifications—hub diameters ½ to 4"... bores ¼ to 2" ...lengths (single) 2 to 10⅝"; (double) 4 to 21¼". All specifications can be altered or special joints designed to individual requirements.

Get this handy guide

It's the quick and easy way to get the Universal Joint that is just right for your application. Request Bulletin 820.

LOVEJOY FLEXIBLE COUPLING CO.
4818 W. Lake St. Chicago 44, Ill.

Circle 487 on Page 19

Vacuum Cleaner Manufacturer Specifies

OSTUCO *Fabricated Welded Tubing*

Bending vacuum cleaner wand. A variety of fabricating operations also is performed on Ohio Special Quality Seamless Tubing.

"Value analysis showed it would be more economical to buy than produce fabricated welded tubing parts for our new cleaner. What's more, we could avoid additional capital investment in equipment.

"So we added Ohio Seamless to our production line. They have the equipment and facilities to meet our design requirements and to hold to our stepped-up schedules. And we don't pay shipping costs on scrap — just on finished parts . . ."

Let Ohio Seamless translate your designs into finished parts . . . conserve your capital . . . cut your production and shipping costs. Contact your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-8847

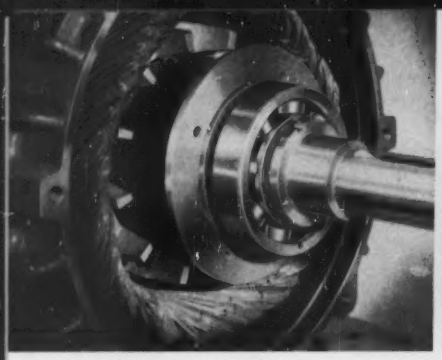
OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

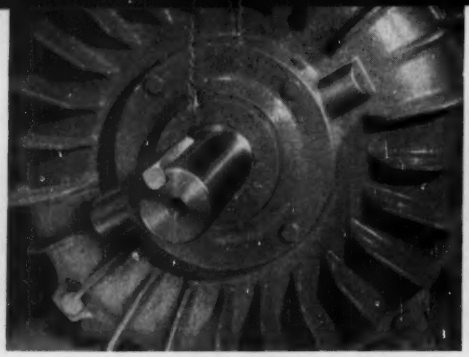
of Copperweld Steel Company · SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

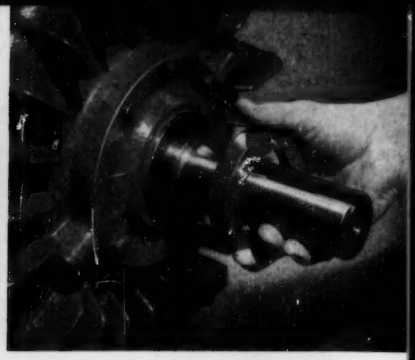
SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, St. Petersburg, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York



HEAVY DUTY BALL BEARINGS . . . The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long trouble-free service under heavy loads.



BEARINGS CAN BE RELUBRICATED . . . Original factory lubrication will last for years in normal service—but convenient grease plugs are provided to permit relubrication that adds to motor life under severe conditions.



SECURELY SEALED FOR LOW MAINTENANCE . . . Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

Wagner Totally Enclosed Motors

Designed to give you Extra Protection

PROTECTED AGAINST CORROSIVE... ABRASIVE AND EXPLOSIVE ELEMENTS

WM59-7

Here are motors that will deliver full-rated horsepower under the toughest service conditions—that will help you keep your production rates up, and give you the kind of dependable, continuous operation that is so important to automation.

Type EP Motors are fully protected against damage from corrosion, dust, abrasives, fumes, steel chips or filings. Type JP is explosion proof as well—is designed and approved for use in explosive atmospheres.

Integral ratings, 1 through 100 horsepower, are built in the latest NEMA frames, 182 through 445 US, with ribs that add mechanical strength and increase the surface cooling area.

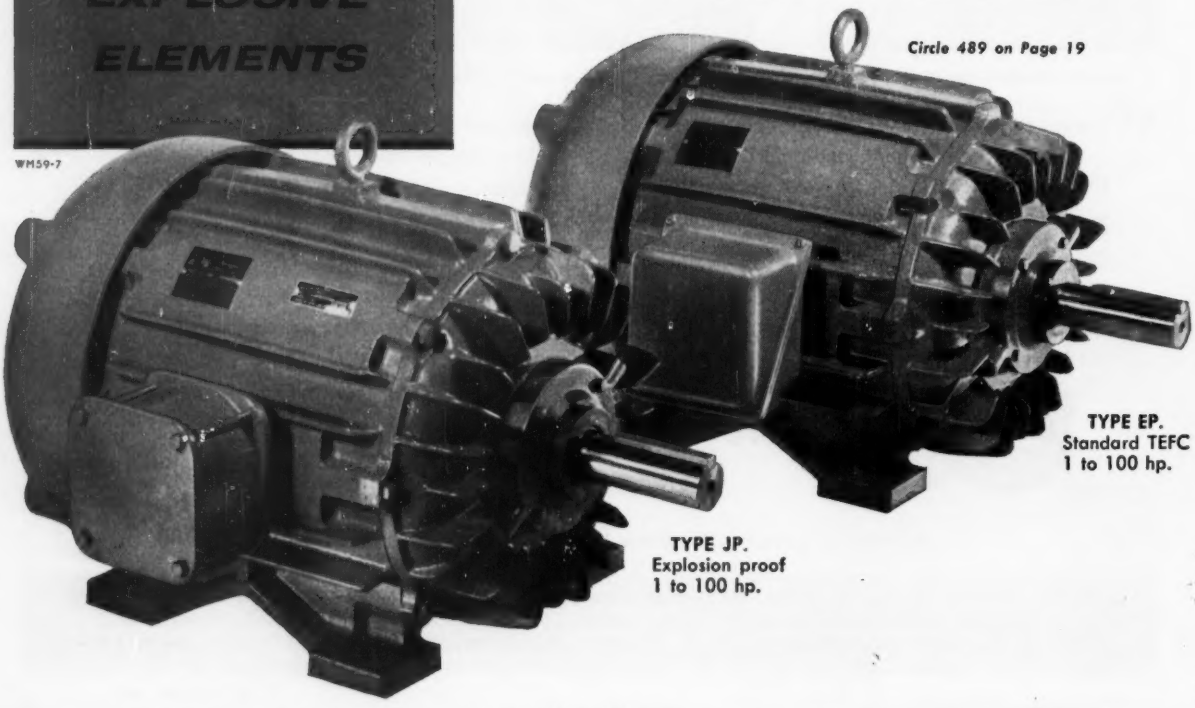
Let your Wagner Sales Engineer show you how these protected motors can bring you savings on initial motor costs, maintenance costs, and in continuity of operation.

Branches and Distributors in All Principal Cities

Wagner Electric Corporation

6404 Plymouth Ave. • St. Louis 14, Missouri

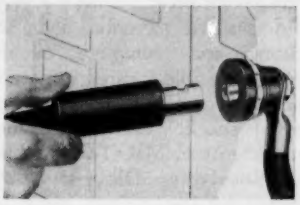
Circle 489 on Page 19



TYPE EP.
Standard TEFC
1 to 100 hp.

TYPE JP.
Explosion proof
1 to 100 hp.

OTHER FRAME SIZES AVAILABLE IN RATINGS THROUGH 500 HP.



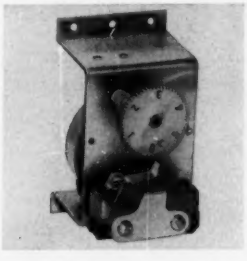
commodate cable sizes from No. 16 to 4/0. **Cam-Lok Div., Empire Products Inc.**, P. O. Box 98, Cincinnati 36, Ohio. G

Circle 642 on Page 19

Time-Delay Relay

incorporates notched dial for simple adjustment

Model FR motor-driven time-delay relay is adjusted by turning indicator lever to desired position on notched dial. The 1¼-in. dial has 60 notched positions and is numbered at every tenth point for easy visibility. Four adjustable timing ranges available are 0 to 15, 0 to 30, 0 to 60, and 0 to 120 sec. Contacts are rated at 20 amp, 480 v noninductive. Synchronous motor



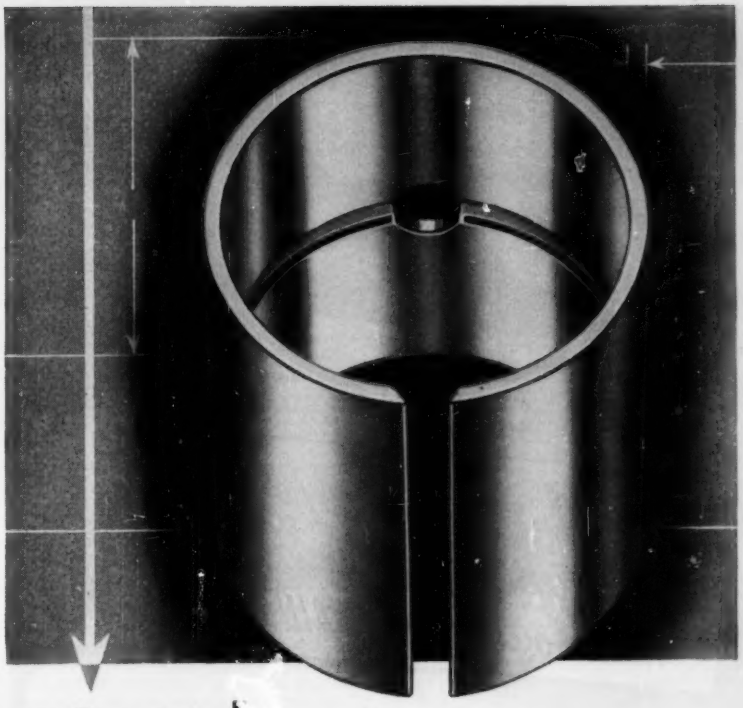
drive provides operation from any standard voltage source. **Zenith Electric Co.**, Dept. MDC, 152 S. Walton St., Chicago 10, Ill. J

Circle 643 on Page 19

Epoxy Compounds

single-component materials need no hardening agents

Hysol 6700 single-component epoxy compounds offer extended stability at room temperature. Both filled and unfilled systems are available, for use without hardening agents. They provide several degrees of flexibility and heat resistance exceeding 150 C. Unfilled compounds are recommended for impregnation of transformers and coils. Filled compounds are recommended for encapsulation of transformers,



extremely rigid specifications!

The illustration shows the cast bronze spindle bearing of a very well-known and popular metal-working lathe.

The manufacturer of this lathe has extremely rigid specifications covering tolerances, finish, structural quality of the bronze and roundness of the bearing even though the bearing is split for its entire length.

A manufacturer with such requirements naturally turns to Bunting to satisfy them.

For the unusual, as well as the usual, in bearings, bushings, bars or special parts of cast bronze or sintered metals, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

...ask or write for your copy of...

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

Bunting®

The Bunting Brass and Bronze Company • Toledo 1, Ohio • EVergreen 2-3451
Branches in Principal Cities

BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS.

Circle 490 on Page 19

MEMO TO L.B.
FROM A.R.
We need one source for all types of chain. How about UNION CHAIN?
You couldn't do better. And here's why. We make all types of steel drive and conveying chain plus sprockets and attachments. We can supply you with the chain you need, whatever the application. And of course it follows from this that our engineering experience is broad and our recommendations are completely unprejudiced. The Union Chain organization is at your service.
TRANSMIT POWER
UNION® CHAINS
CONVEY MATERIALS
Consult Your Nearest Union Chain Distributor
The Union Chain And Manufacturing Company
P. O. BOX 651, SANDUSKY, OHIO

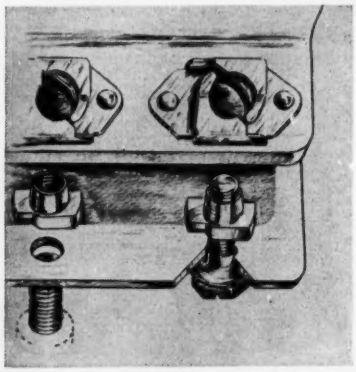
strain-sensitive torroidal coils, capacitors, and complete circuits. Tough, flexible cured material eliminates cracking during severe thermal shock. Compounds meet requirements of MIL-T-27B. **Electrical Insulating Div., Houghton Laboratories Inc.**, Olean, N. Y. N

Circle 644 on Page 19

Panel Fastener

quick-release unit is nut and basket retainer

Type FR quick-release panel fastener is for use on access doors and removable panels of busses, trucks, trains, and other mobile equipment. The rugged, two-piece unit, consisting of a nut and basket retainer, is simple to install, and has no springs or pins to break or distort. As bolt is rotated, self-locking nut turns from entry slot of basket and lifts on beveled edge of nut lugs into basket recess. Lifting action



of nut draws up screw and attached cover plate into firm, positive contact with base plate at desired preset loading. Fastener requires only a quarter-turn of bolt to complete lock-unlock action. It is presently available in ¼-20 thread size, with ¼-28 thread soon to be furnished. **Elastic Stop Nut Corp. of America**, 2330 Vauxhall Rd., Union, N. J. D

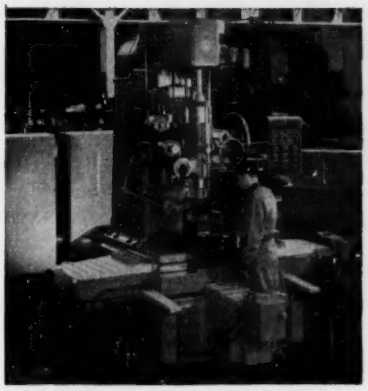
Circle 645 on Page 19

Wiping Unit

for hydraulic cylinder rods

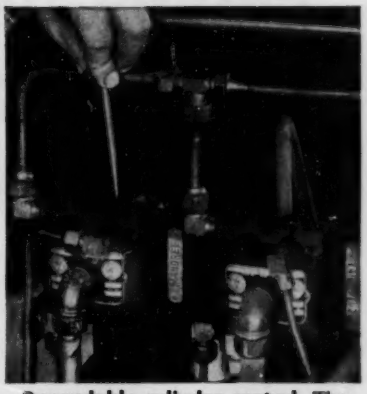
Seal-Guard is a two-bladed wiping unit which clears dust, grit, weld spatterings, mud, and ice from reciprocating rods. Two bronze blades fit snugly around cylinder rod and seat in a recess machined into

Why Skinner 4-way solenoid valves are used so widely for cylinder control

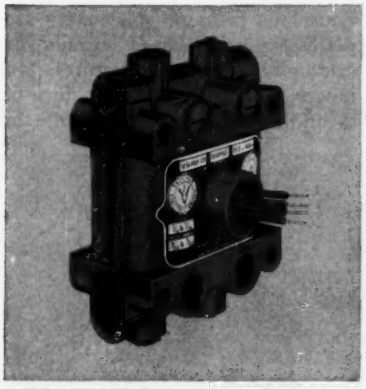


Application: A longitudinal and a transverse slide in this Pratt and Whitney Electrolimit Jig Borer is positioned automatically from numerical data on punched tape or manually by decade dials. When each slide has been correctly positioned it is held firmly by air-actuated, non-influencing clamps. Each clamp is controlled by a cylinder and a Skinner four-way V9 valve.

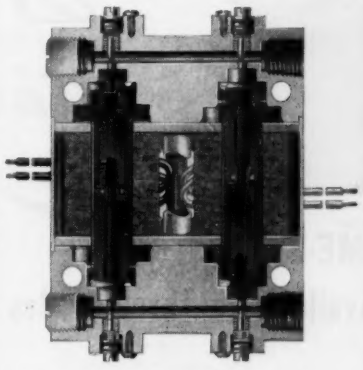
Features of standard valve did job. No special engineering of the four-way V9 valve was required to meet Pratt and Whitney's need. Molded oil-proof coils are used to guard against burnout from cutting solutions. The Skinner valve makes an ideal cross connection between electrical sensing and the muscular air required to provide the clamping action.



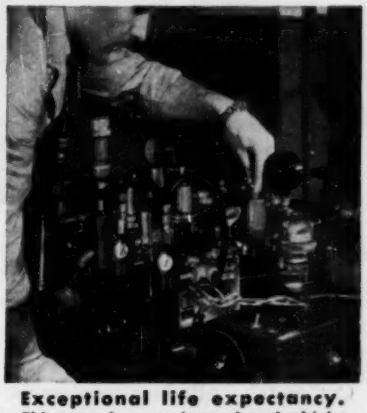
Dependable cylinder control. The four-way V9 valve is available with adjustable flow features in the main stream and in the exhaust passage for exceptionally accurate cylinder control. Position of inlet and exhaust connections can be changed easily in the field by simply reversing plugs.



Skinner V9 four-way valves, actually two 3-way valves in one housing are offered normally closed-normally closed, normally open-normally open, and normally closed and normally open. Media: air, inert gases, hydraulic fluids and vacuum; orifices: 3/64" to 1/8"; NPT ports: 1/4"; pressure ratings: to 250 psi. Over 350 basic variations.



Quality workmanship throughout. Internal parts are stainless steel and highly corrosion-resistant. Durable, compressible inserts of soft, synthetic materials insure bubbletight operation. Orifice seats have radius with well-rounded contact area and high finish for long insert life. Valve can be mounted in any position.



Exceptional life expectancy. Skinner valves, engineered to the highest UL standards, are life-cycled in the lab at speeds as high as 600 cycles per minute. In these tests, the V9 valves regularly get over 20-million cycles without leakage. And these results are constantly proving out in service.

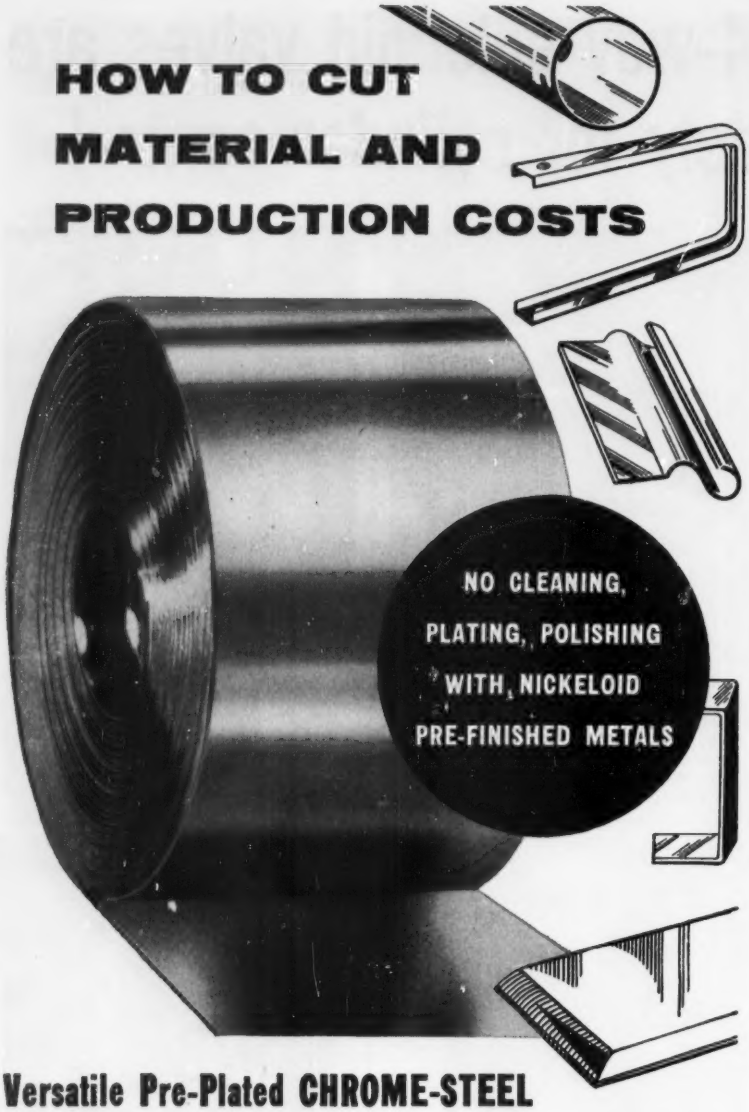
Skinner solenoid valves are distributed nationally.

For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 421.

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
105 EDGEWOOD AVENUE

HOW TO CUT MATERIAL AND PRODUCTION COSTS



Versatile Pre-Plated CHROME-STEEL and NICKEL-STEEL Now Available in Three Grades

Cut costs! — Reduce production steps! The *need* was never greater; the *method* never surer than with Nickeloid chrome-steel and nickel-steel . . . now available in C-grade, *a new low-cost utility grade* for applications that don't require the quality of our A and B grades. These cost-cutting design materials are *pre-finished* — eliminate extra handling, cleaning, racking and polishing costs, plus actual plating costs. So versatile — adaptable to standard production methods, too! Their beautiful durable finishes can add so much in sales and utility value to your products at very low cost. Cut costs, reduce production steps with Nickeloid chrome-steel or nickel-steel — big 24" wide coils, sheets, strips; bright and satin finishes. Now save even more with new low-cost C-grade!

NICKELOID METALS SINCE 1896 N•M

Write For More Information

AMERICAN NICKELOID COMPANY

PERU 8, ILLINOIS

MILLS — Peru, Illinois and Walnutport, Pennsylvania Sales Offices Throughout the U.S.A.

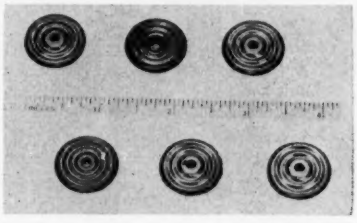
gland ring. Rubber retaining ring snaps over blades and down into recess, holding blades in place. Retainer also acts as a cushion which absorbs shock and side loads while providing an over-all outside unit seal. Temperature range of the unit is from −40 to 250 F. It is available in any size for ½ to 24 in. shaft diameters. Sizes change in increments of 1/16 in. up to 6 in. and in increments of ¼ in. from 6 to 24 in. diam. **E. F. Houghton & Co.**, 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 646 on Page 19

Pressure Elements

with OD of 7/8 in.

Capsular pressure elements are available for either internally or externally applied pressures, in ranges from 15 to 350 psi. Size of the units is ⅞ in. OD, for use in



miniaturized applications. Elements have excellent linearity and low hysteresis. **Aircraft Components Div., Bristol Co.**, Waterbury 20, Conn. B

Circle 647 on Page 19

Adjustable-Speed Drive

miniature unit provides wide speed range

Servotran miniature adjustable-speed drive weighs only 1¾ lb, and is 3¾ in. long by 2 in. in diam, without motor. Maximum of 2 oz-in. on the control shaft changes speed from full forward to full reverse in 0.05 sec. Output torque is

Circle 493 on Page 19

Circle 494 on Page 19→

KL—A VERSATILE, RELIABLE, LOW COST P&B RELAY

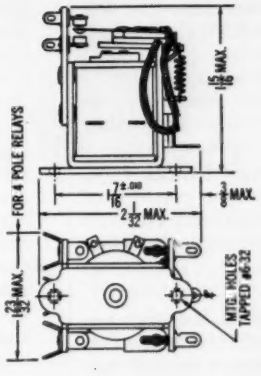
for communications and automation

ECONOMY and versatility distinguish our KL series relays. Contact arrangements are available up to 4 pdt in either AC or DC versions. Sensitivity of 100 milliwatts per movable arm is available.

Stationary contacts and terminals are mounted on a phenolic front of high dielectric strength, thus adding to the utility of the relay. Conveniently located terminals and easy-to-mount base greatly simplify installation on long production runs.

KL relays may be hermetically sealed or furnished in metal dust covers.

This is one of a "family" of fine P&B relays. Others, with similar configurations but various electrical and switching capacities, are shown below. Write or call for more information or see the complete P&B catalog in Sweet's Product Design File.



KL ENGINEERING DATA

GENERAL: Breakdown Voltage: 500 volt rms, 60 cycle between all elements standard 4 pole relay; 1500 volts rms, 60 cycle on special 3 pdt relay.

Temperature Range: −45°C. to +85°C.

Pull-in: Approx. 75% of nominal dc voltage. Approx. 78% of nominal ac voltage.

Terminals: Pierced solder lugs for two #20 AWG wires.

Enclosures: Metal can 2 3/16" high x 2 3/8" long x 2 1/32" wide with octal plug or multiple solder header.

CONTACTS: Arrangements: up to 4 pdt.

Material: 1/8" dia. gold-flashed silver. (Others available.)

Load: 5 amps @ 115 volts, 60 cycle resistive loads.

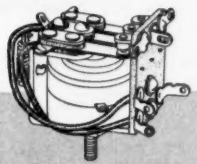
COILS: Resistance: 60,500 ohms max.

Power: 100 milliwatts per movable arm.

Duty: Continuous; coils will withstand 6 watts @ 25°C.

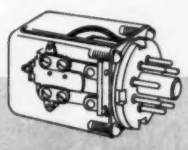
Voltages: up to 110 volts dc. up to 230 volts ac.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



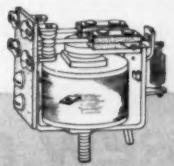
KR SERIES: SMALL, 5 AMP RELAY

Ruggedly constructed for long life and dependability. Available up to 3 pdt.



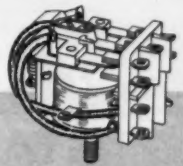
KCP SERIES: SENSITIVE 3 PDT RELAY

For plate circuit applications requiring low cost, sensitive relay. Polyethylene dust cover.



KT SERIES: ANTENNA RELAY

Insulated to minimize RF losses. Designed to switch 500 watts RF input to 300 ohm line.



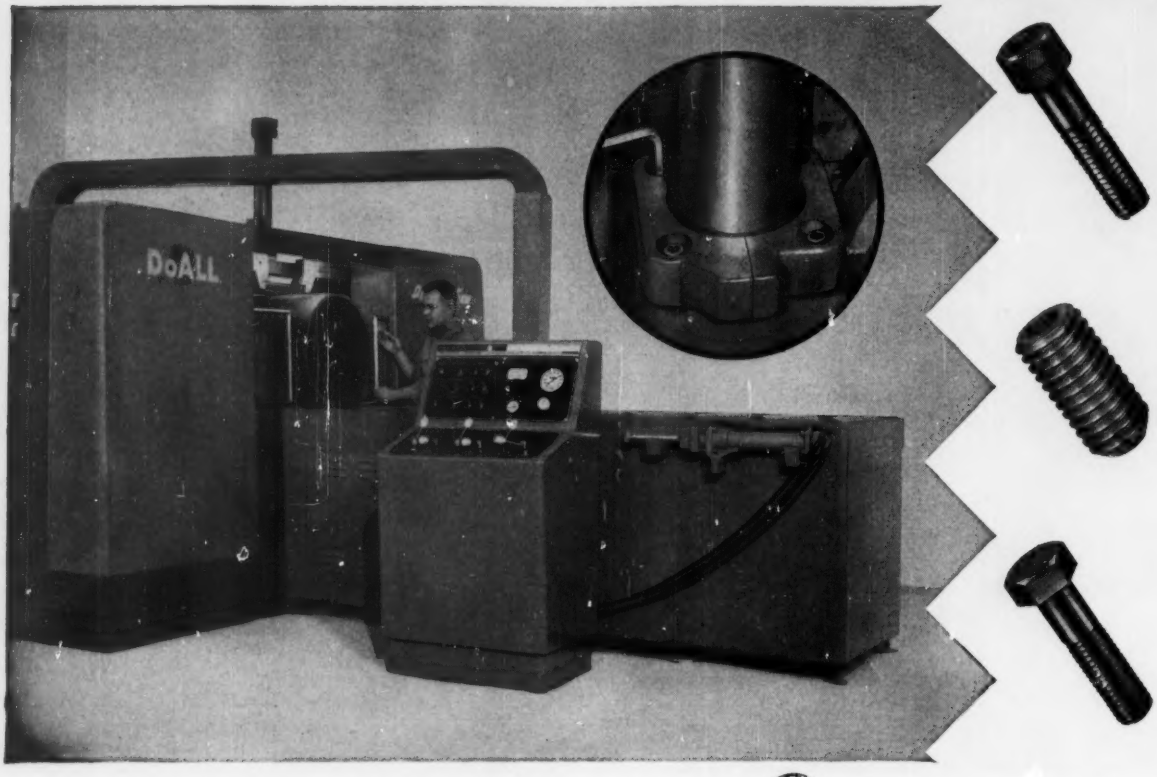
KA SERIES: GENERAL PURPOSE

Compact, light-duty relay. U/L approved. Meets 1500 volts rms breakdown requirement.

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

IT PAYS TO STANDARDIZE ON **STANSCREW**



Stanscrew fasteners meet DoALL standards for high strength, rigidity, "clean" design

This outstanding machine was developed by the DoALL Company to handle industry's largest, toughest cut-off jobs. Not a beefed-up model of existing machines, this "biggest band saw built" is a unique new design. As one example, the cutting head travels vertically, but cutting takes place on the lower edge of the top saw band.

The new design of this unit, Model C24, therefore represents an entirely new concept of rigidity, applied power, and precision control. These basic considerations dictated the selection and application of every part . . . including, of course, the fasteners.

Small wonder, then, that DoALL's design engineers, after consultation with Stanscrew's fastener specialist, selected Stanscrew socket cap screws for vital applications such as attaching hydraulic cylinders. These reliable fasteners provide the high strength needed. Correctly applied, they give assurance against misalignment even after extensive use—a must in this precision machine. And, by permitting flush, snag-free surfaces, the fasteners also contribute to the C24's superior styling.

Like DoALL, other leaders of American industry are learning the advantages of calling in a Stanscrew specialist when a new product is on the drawing boards. His wide experience can often suggest ways to cut fastener or assembly costs . . . for example, by substituting a standard fastener for a costly special. He can make suggestions from Stanscrew's complete line of over 4,000 types and sizes, always in stock and quickly available.

So whatever your requirements in fasteners, call your Stanscrew distributor today. He will gladly arrange for a prompt visit from the Stanscrew fastener specialist.

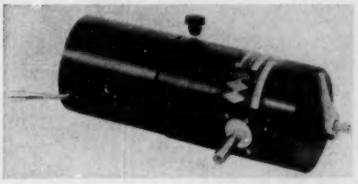
STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 495 on Page 19

constant and efficiency is between 85 and 95 per cent. Unit is available with several modifications to meet specific needs. Applications include actuators, computers, recorders, integrators, and airborne



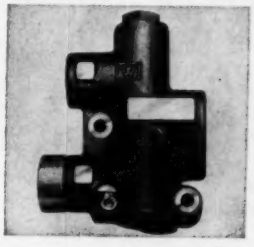
instrumentation where low torque shifting, high efficiency, wide speed range and low noise levels are required. **Humphrey Products Div., Humphrey Inc.**, 3794 Rosecrans St., San Diego 10, Calif. L

Circle 648 on Page 19

Relief Valve

has manually operated knob for quick pressure-setting change

Pilot-operated relief valve is available in two sizes with capacities of 0 to 20 and 0 to 60 gpm. A twist of a manually operated knurled knob changes pressure settings quickly from 500 to 2000 psi without use of tools. Valve, designed especially for use with machine



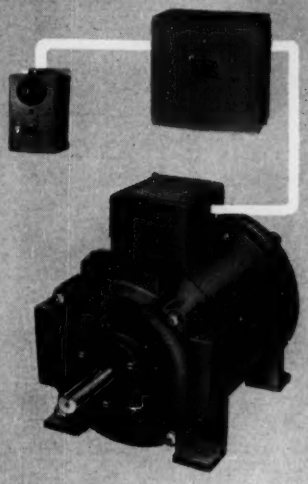
tools, provides minimum pressure drop and instantaneous response when peak load is reached. **Hydraulic Div., Webster Electric Co.**, Racine, Wis. K

Circle 649 on Page 19

Miniature Terminal Boards

have four or eight terminals molded into body material

Series MT miniature terminal boards have voltage breakdown at sea level of 2500 v rms, and 600 v rms at 60,000 ft. Boards have four (shown) or eight turret terminals molded directly into body material, and ⅛-in. diam mounting holes can be supplied on either



PRECISION

ELECTRONIC

ADJUSTABLE-SPEED DRIVES

- **SPEED RANGE** Infinitely adjustable from less than 36 rpm to more than 3600 rpm while delivering full rated torque. Continuous duty rating at all speeds.
- **REGULATION** Both line and load regulation is better than ½ of 1% of rated speed.
- **HORSEPOWER** Various models from ¾ hp down to 1/200 hp. Motors of ¼ hp and larger are totally enclosed.
- **REMOTE CONTROL** A 10-turn potentiometer provides precise adjustment at any convenient location.
- **GEARED MOTORS** Motors are available with integral gear reducers.
- **BRAKING-REVERSING** Relay-controlled braking and reversing models available.
- **MAINTENANCE** Fully encapsulated construction results in long service life. Plug-in construction requires only a screwdriver for servicing.
- **OTHER MODELS** Servo-Tek manufactures drives with silicon rectifiers and adjustable autotransformers, as well as other thyratron drives with less exacting specifications. Write for information including details of your proposed use.

IMMEDIATE DELIVERY

Servo-Tek PRODUCTS CO. INCORPORATED

Main Office
1086 Goffle Road, Hawthorne, N. J.
Western Office
14736 Arminta Street, Van Nuys, Cal

Circle 496 on Page 19

- POLYCARBONATE
- POLYPROPYLENE
- RIGID POLYVINYL CHLORIDE

New MATERIALS IN PLASTIC EXTRUSIONS

If you are planning to use any of the newest materials, Anchor can help you. Anchor is already experienced in working with these recently developed plastics and is fully equipped to extrude sample runs for you. Should you want to try out your ideas in extruded shapes, tubes, rods or strips, Anchor's Design Engineers will be pleased to show you how to get a quality product . . . inexpensively.

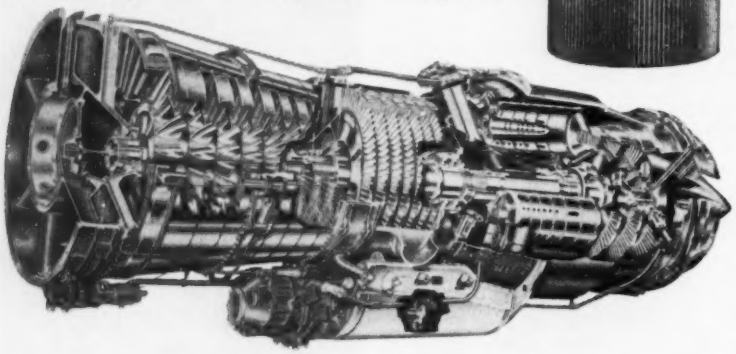
ANCHOR PLASTICS CO., INC.
36-36 36th Street
Long Island City 6, N. Y.
RAvenswood 9-1494

Circle 497 on Page 19

PRECISION for top-flight performance!

Rigid PRATT & WHITNEY AIRCRAFT precision requirements spell *performance* . . . top-flight performance. Reason: The future is at stake. And that future can well ride on gear teeth. Since 1940, PRATT & WHITNEY AIRCRAFT gear tolerances have been *Perkins'* standards . . . for commercial gears as well as aircraft. Such precision pays off in longer wear, greater efficiency, lower maintenance cost. That type of precision can pay off for you, too.

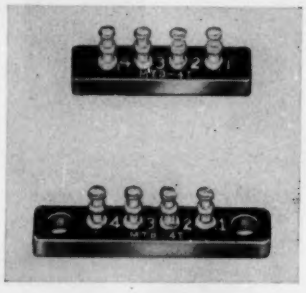
Famous PRATT & WHITNEY AIRCRAFT J57 Jet Engine, power plant for Air Force "Snark" guided missile, is geared for both commercial and military performance by *Perkins*. Typical tolerances on *Perkins* gears: .0004 tooth to tooth; .0015 cumulative; .0005 on involute. On spline: .0006 tooth to tooth; .0008 cumulative; .0005 on involute. Most *Perkins* gears are carburized, hardened and ground.



YOURS ON REQUEST
Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept. 63 West Springfield, Mass.
Telephone: REpublic 7-4751



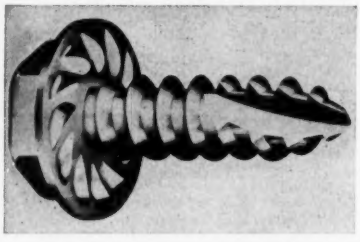
size. Standard molding compound is mineral-filled melamine (MIL-M-14E, Type MME). Other configurations, modifications, and molding compounds are available to meet special requirements. **Electronic Sales Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 650 on Page 19

Self-Tapping Screw

eliminates stripping as it drills

Type 17 Nibscrew taps its own hole in soft wood, particle board, and some plastics, and eliminates stripping as it drills. Screw incorporates nibs under the head that absorb excessive driver torques, and self-drilling point that eliminates predrilling of secondary holes. In soft or thin materials, nibs provide braking action for screw by increas-



ing stripping torque two to four times that of regular heads. Screw does not strip the hole, and full holding strength is retained. **Shakeproof Div., Illinois Tool Works**, St. Charles Road, Elgin, Ill. J

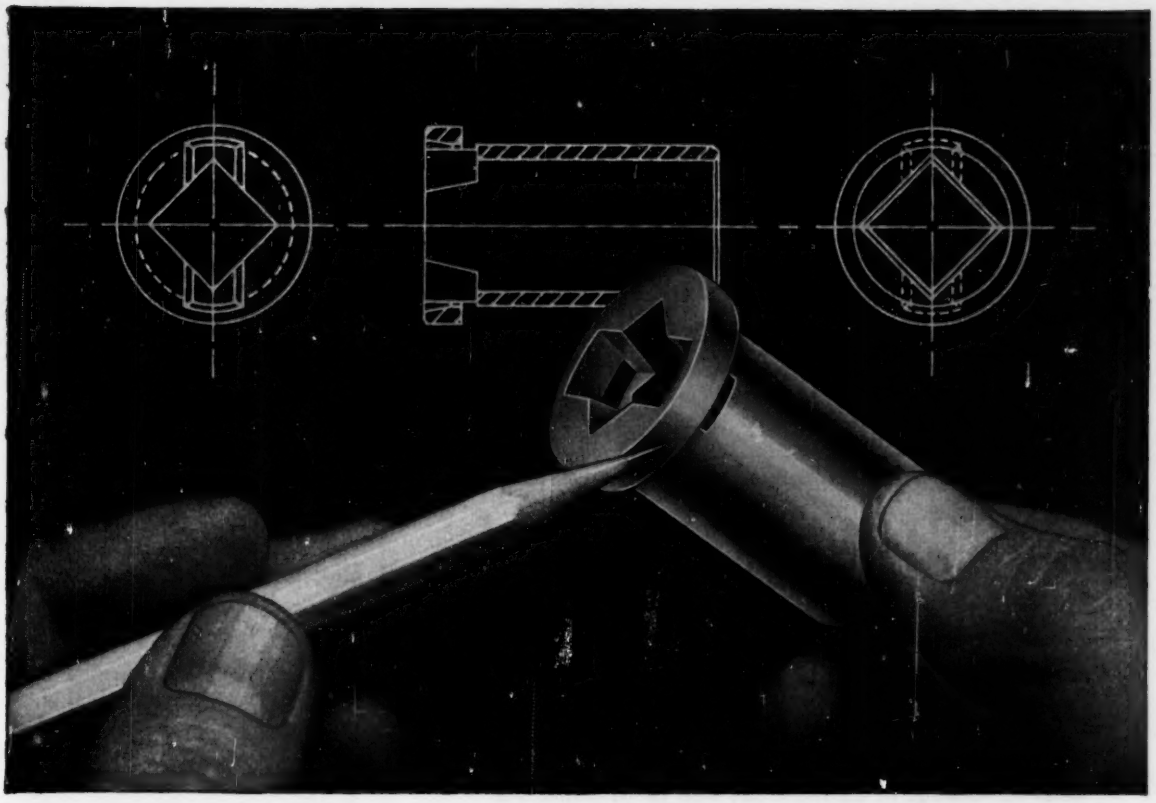
Circle 651 on Page 19

Silicon Solar Cells

convert 10 per cent or more of surface radiant energy

Rectangular silicon solar cells are available for both commercial and military applications, and provide an output of about 9 w per sq ft

Circle 498 on Page 19



How Would YOU Produce This Part With No Machining . . . No Scrap Metal?

PARKER SALES ENGINEERS

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street
CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street
DAYTON 4, Ohio
William C. Twiss • 915 Valley Street
DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens
GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street
LONG BEACH 11, California
R. W. Fletcher • 2803 Loomis Avenue
MINNEAPOLIS 16, Minn.
O. R. Kreutziger • 6524 Walker Street
PHOENIX, Arizona
Fred B. Larsen • 6108 North 11 Avenue
ST. LOUIS 8, Mo.
Frank May • 4378 Lindell Boulevard
SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.
WILTON, Conn.
Girard L. Palmer • Belden Hill Road
WINTER PARK, Florida
Duane P. Davis • 110 South Orlando Avenue
Box 26

Can't be done? Parker did it . . . sharp internal corners, lateral holes, chamfers, flanged end and all . . . by fast, low-cost powdered metal pressing and sintering. No subsequent machining . . . no scrap-metal loss. Just think of the savings compared with conventional machining methods.

In addition to these inherent cost savings, Parker-engineered Powdered Metal Parts offer a wide choice of tensiles, ductility, density, impact resistance and other physicals. Tooling-up is done quickly and at relatively low cost.

It will pay you to check on the economies and design possibilities of Parker-engineered Powdered Metal Parts. Just call the nearest sales engineer listed here or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

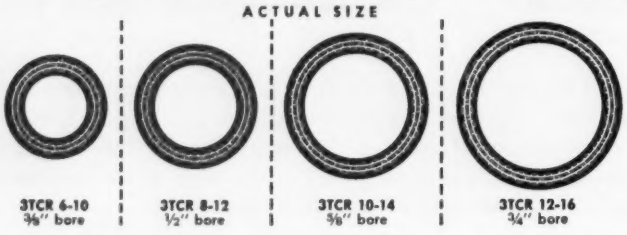
Circle 499 on Page 19

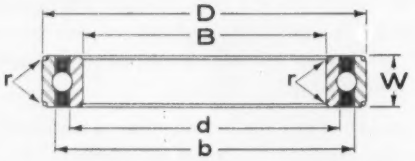
small bearings for big jobs

Thin-section **midget** T series precision ball bearings were designed primarily for instrument application, and to bring new, high standards of performance to their size range. Actual sales experience has shown a much wider range of application for these versatile bearings than heretofore anticipated.

These bearings feature: (1) light, one-piece retainer with true maximum ball complement — good for low torque values. (2) savings from 46% to 90% on space requirements, compared with conventional inch-series ball bearings of equivalent bore size. (3) no loading slot or other design compromise which might limit thrust capacity. (4) high ratio of load capacity to bearing volume. (5) rings and balls of stainless steel; retainer of pressure-molded fibre-reinforced phenolic. Made in precision and ultra-precision grades.

For complete information, get our catalog 59 . . . Write today.



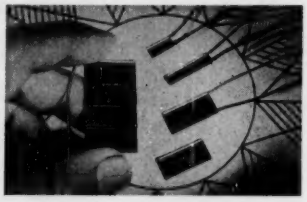


*B bore ± .0002	*D o.d. + .0000 − .0004	W width + .0000 − .0050	†r radius	b outer land ± .001	d inner land ± .001	Balls no.	Balls size	‡L lbs.	§S lbs.
.3750	.6250	.15625	.010	.542	.457	16	1/16	77	110
.5000	.7500	.15625	.010	.672	.587	21	1/16	89	144
.6250	.8750	.15625	.010	.797	.712	24	1/16	94	165
.7500	1.0000	.15625	.010	.922	.8375	30	1/16	101	206

Dimensions are in inches. *Tolerances shown are for Precision Grade. Write for Ultra Precision Grade tolerances. †r is maximum fillet radius on shaft or housing that bearing will clear. ‡Radial load capacity at 500 rpm and 2500 hours average life. §Static non-Brinell load capacity.

split ballbearing
A DIVISION OF MPB, INC.
308 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE

of active cell area in bright sunlight. They convert 10 per cent and more of radiant energy falling on surface. Individual cells are ob-



tainable, with or without color-coded pigtail leads, in sizes ½ x 1, ½ x 2, and 1 x 2 cm. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 652 on Page 19

Miniature Blowers

provide high efficiency at low flows

Series 300 miniature, low-flow centrifugal blowers are aluminum units which provide pressures up to 110 in. of water (4 psi). Over-all width is 4 in., length, 5½ in., and weight, 2½ lb including motor. Unit shown generates 55 in. of water pressure with flow of only 7 to

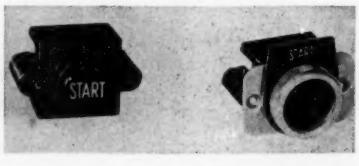
20 cfm. A 1/10-hp, 400-cycle ac, or 12 and/or 24-v dc motor drive the twin blowers. **Sawyer-Bailey Corp.**, 1559 Niagara St., Buffalo 13, N. Y. F

Circle 653 on Page 19

Single-Element Pushbuttons

for nonoiltight standard-duty use

Single-element pushbuttons are



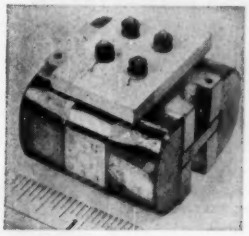
available for standard-duty, general-purpose ac and dc control circuits. They are intended for individual or flush-panel mounting in nonoiltight standard-duty applications. Black molded phenolic base contains momentary double-break, silver-to-silver contacts rated at 3 amp 120 v ac. **Ward Leonard Electric Co.**, 115 MacQuesten Parkway South, Mount Vernon, N. Y. D

Circle 654 on Page 19

Torque Motor

operates at 600-F temperatures

Model 103-2 torque motor permits the use of electrohydraulic or electropneumatic servo valves or similar devices in high-temperature applications, without need for compli-



cated cooling systems or thermal lag provisions. It operates at temperatures to 600 F. Unit has mid-position force of over 8 lb and stroke of ±0.008 in. at a radius of 0.750 in. It measures 1⅛ x 1 11/16 x 1¾ in., weighs 10 oz, and requires only 4 w input electrical power. **American Measurement & Control Inc.**, 240 Calvary St., Waltham, Mass. B

Circle 655 on Page 19

Limit Switch

for exposed control or indicating applications

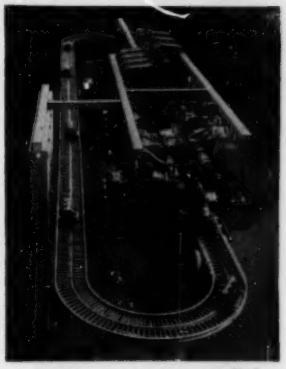
H11 limit switch is designed for any exposed control or indicating application on aircraft or industrial machines. Component offers sealed dependability, adjustability, ruggedness, and environment-free characteristics. Use of stainless steel or Monel for all exposed parts provides corrosion resistance. Heliarc welding provides positive sealing and added strength. Switch mounts anywhere through one mounting hole, infinitely adjustable within ⅞ in., wire locking. Multiple circuit control supplied by

STEEL *from Wheelock, Lovejoy*
BULLETIN

W-L DETROIT For the first time, HY-TEN D-2 air hardening steel now available here in rounds, squares, flats and billets. Also a fine stock of standard alloy grades, especially A-8620, as well as all HY-TEN grades. Excellent service from our new warehouse.

W-L CHICAGO Steady demand for "B" No. 3X for flame-hardened parts such as boring bars. Good stocks of HY-TEN AIS—the best carburizing alloy steel, and freest machining available today—a new W-L exclusive!

W-L CINCINNATI This 23-station Avey Line-O-Dex transfer machine, designed and built by The Avey Division of Motch & Merryweather Machinery Co., Cincinnati, Ohio, is equipped with spindles made of our HY-TEN "B" No. 2. This grade was chosen for its great tensile strength (100,000 P. S. I. in the natural condition), toughness, and fine wearing qualities.



W-L CAMBRIDGE We are now distributing FLEXANGLE, the easy-to-erect structure assembly for all types of racks, shelves, platforms, etc. It's completely universal and low in cost—can be used anywhere, by anyone, for any storage purpose.

W-L HILLSIDE Our stock of flat and square sizes in HY-TEN M Temper Oil Hardening Steel can save you time and money in your tooling program. HY-TEN "B" No. 3X pre-heat treated in rounds, squares and flats available in a wide range of sizes. Billets on hand for hammer forging in all grades of HY-TEN.

W-L CLEVELAND Excellent stock of brake die flats and squares. Also many sizes up to 16" x 18" in HY-TEN Mold Steel. Excellent deliveries.

W-L BUFFALO A wide range of rounds and hexagons in cold drawn AISI leaded and non-leaded A-4140. Also many sizes of the new "B" No. 3X-40 in rounds and hexagons.

Write our Cambridge office today for your *free* Wheelock, Lovejoy Data Sheets. They'll give you complete technical information on grades, applications, physical properties, tests, heat treating, etc.

WHEELOCK, LOVEJOY & COMPANY, INC.
134 Sidney Street, Cambridge 39, Mass.

AMERICAN STEEL WAREHOUSE ASS'N

AGENTS: Southern Engineering Company, Charlotte, N. C.; Sanderson-Newbould, Ltd., Montreal & Toronto

Circle 501 on Page 19

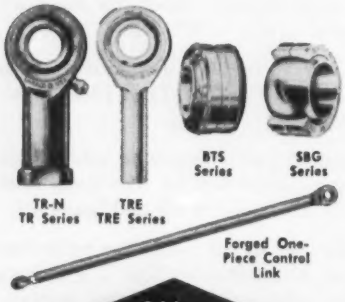
Component reliability begins with

SPHERCO®

SPHERICAL BEARINGS and ROD ENDS

Cutaway View of TRE Male Rod End

- Precision-built for superior performance.
- Solid race construction
- Wide range of designs, bore sizes, materials, etc.
- Prompt delivery schedules
- Engineering service



Write FOR CATALOG 257

SPHERCO

A PRODUCT OF SEALMASTER BEARING DIVISION STEPHENS-ADAMSON MFG. CO.

18 RIDGEWAY AVE. • AURORA, ILL.

Circle 502 on Page 19

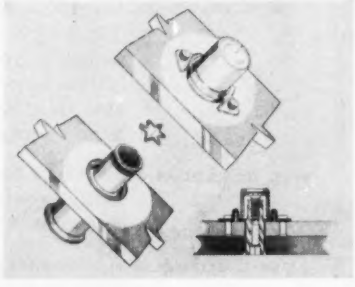
separate terminals permits many circuit combinations. Ambient temperature range is −100 to 221 F. **Switch Div., Electrosnap Corp.,** 4230 W. Lake St., Chicago 24, Ill. J

Circle 656 on Page 19

Structural Panel Fastener

is three-piece, multiple-turn unit

New fastener consists of internally threaded sleeve bolt, preassembled receptacle, and retaining ring. Sleeve bolt is inserted through panel to engage threaded stud on interior of receptacle and is then rotated to lock assembly. When disconnected, sleeve bolt winds itself out of panel to eliminate bind. Fastener permits panel misalignment of



up to 0.040 in. The alloy-steel unit is furnished for shank diameters of ¼ and ⅜ in., for panel thicknesses from ⅛ to 1⅛ in. It is for applications to 700 F. **Nutt-Shel Co.,** 2701 S. Harbor Blvd., Santa Ana, Calif. L

Circle 657 on Page 19

High-Strength Insulator

meets Mil Spec MIL-P-14B-Type CFG

B1-1000 impact-resistant phenolic insulator consists of bakelite insu-

Servospeed
HEART OF AUTOMATION
MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL
1/100 — 10 H. P.
Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.
Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989

Circle 503 on Page 19

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **A plastic for potentially hazardous locations**
- **Material for a non-warping switch**
- **More design freedom in metal castings**

Canopy retards fire

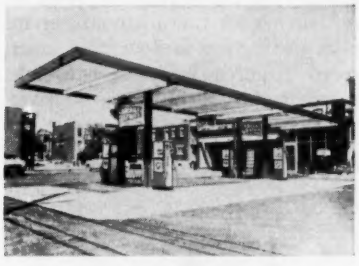
Good product ideas seem to work almost anywhere.

Take, for example, this plastic gas-station canopy. So far as we can tell, the idea of cool, light-diffusing canopies over the gas pumps started in the South, where it would seem to be a natural.

However, the canopy you see here is in Canada. It does most of its work in winter, when it may have to hold up the weight of five feet of snow and ice.

The marketing strategy is sound. A motorist doesn't mind so much getting out of his car in bad weather when he's protected overhead; and the attendant, too, is likelier to provide that extra bit of service.

There's something else that's different about this canopy. It doesn't support combustion, because it's made with Hetron® self-extinguishing polyester resin. A fire starting at a pump won't spread along the canopy to other pumps or to the station building.



If it weren't for self-snuffing Hetron, there'd be few places where a good idea like this could operate. Fire retardance is chemically locked into the resin, not added later at the expense of strength. The resulting combination of structural properties gives you something unique on which to base *your* new-product ideas.

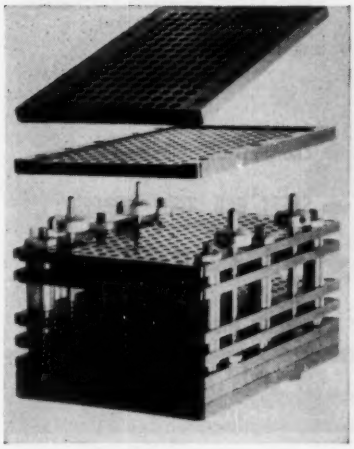
If you'd like to know more about Hetron resins, let us send you the complete technical data file, together with names of leading fabricators in this country and Canada who can make U/L-listed panels and custom-molded shapes for you.

Less dough for this "bread"

Needed: a dimensionally stable material for the "bread" in this sandwich-like multiple switch assembly (above right).

Why dimensionally stable? Because each of the seven "slices" in the sandwich has 187 holes that must line up with matching holes in the other plates.

What low-cost insulating material would hold alignment without risk of moisture absorption and warping? Could



holes be *molded,* rather than drilled, to the required accuracy? Would this save money?

The material recommended by the custom molder was a fast-curing Durez compound with good moldability and excellent dimensional stability. This material does everything the designers want it to do. Its exceptionally good mold release facilitates the low-cost molding of holes. In addition, numbers and letters which were formerly silk-screened on the plates are now molded-in for extra savings.

Result: a smooth-functioning, non-warping switch, produced with the utmost economy. It's just one more proof of the wide, wide spectrum of design requirements you can meet at low cost with Durez phenolics (and often *only* with phenolics). Want more information on these versatile molding compounds? Just check the coupon for a bulletin on Durez materials.

Castings – can do

Don't back off from a complex metal shape just because "it can't be done."

Instead, talk to your foundryman. He may have a surprise up his sleeve—*shell molding.* It saved the day for the aluminum-alloy gearbox cover, below.

Designers wanted as many heat-dissipating fins as possible; they compromised on 40. Even so, fins tore when the piece was poured in sand. Three men could produce only 20 good castings a day.

A switch to shell molding has made the casting economically feasible. Three men now turn out 70 per day. Dimensions are much more consistent from one casting to the next. As a bonus, engineers found they could squeeze two more fins into the design to get higher efficiency than they first believed possible.

What about cost? Shell-molded castings sometimes cost more *per pound* than regular castings. But they often save you far more than the difference—by reducing machining and finishing time and by speeding assembly.

Like to know how these better castings are made with the help of Durez foundry resins? We'll gladly send you the new 36-page "Durez Guide to Shell Molding" if you check the coupon below.

For more information on the Durez materials mentioned above, check here:

- ☐ Hetron fire-retardant polyester resins (50A)
- ☐ General bulletin on Durez materials (Bulletin 400)
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)

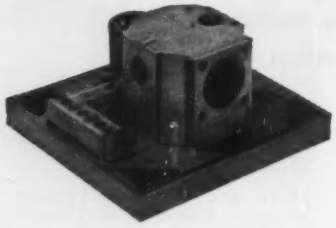
Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
501 Walck Road, North Tonawanda, N. Y.

Circle 504 on Page 19

LRC LUZERNE
PLASTICS AND HARD RUBBER



◆ MOLDED PARTS
Specialists in heavy intricate CUSTOM PARTS, Heat-Resistant HARD RUBBER (264°F. — A.S.T.M.) PVC and other PLASTICS, Long and short runs.

PVC PART 14" square x 9" high 15 LBS.

◆ PIPE, FITTINGS, VALVES
◆ LINING TANKS, PIPE, CASTINGS
◆ ROLL COVERING
◆ FABRICATION, MACHINING
◆ SHEET, ROD, TUBE, SHAPES
◆ ENGINEERING DESIGN

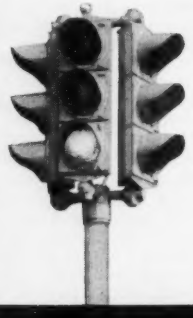
WRITE Dept. MD FOR INFORMATION OR SEE US IN CHEMICAL ENGINEERING CATALOG

LUZERNE RUBBER COMPANY
MAIN OFFICE AND FACTORY — TRENTON, N. J.

Circle 505 on Page 19

Neither dust, dirt, moisture nor temperature changes can affect an Adlake relay. Hermetically sealed mercury-to-mercury contact is quiet, chatterless . . . can't burn, pit or stick. A-plus qualities backed by a century of service. What's your control problem? Write today. No obligation.

a lot at stake?



NO. 1140, one of 4 basic models designed to your control needs.

depend on A+ Adlake mercury relays and controls

SEND FOR FREE CATALOG J-8901
Adams & Westlake
Elkhart, Indiana

Circle 506 on Page 19

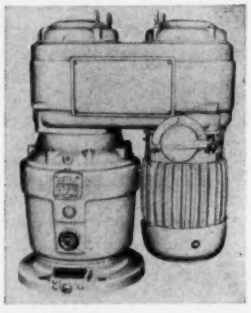
lator body and 16-gage steel, cadmium - plated, die - formed base. Threaded brass inserts are molded into insulator body. Unit meets MIL-P-14B-Type CFG. **Mullenbach Div., Electric Machinery Mfg. Co.,** 2100 E. 27th St., Los Angeles 58, Calif. L

Circle 658 on Page 19

Adjustable-Speed Drives

are rated 3 to 30 hp at 30 to 380 rpm

Packaged adjustable-speed drives, designated vertical Varidrive-Syncrogear, combine a high-speed ac motor, mechanical-type adjustable-speed transmission, and double-reduction gearing. Units offer advantages in applications where variations exist in temperature, viscosity, batches, or raw materials, or in pilot production to determine exact speed required before a constant-speed motor is installed. Drives



connect to any three-phase ac power source. Power ranges from 3 to 30 at 30 to 380 rpm, with speed variations from 2:1 to 7:1. **U. S. Electrical Motors Inc.,** Box 2058, Terminal Annex, Los Angeles 54, Calif. L

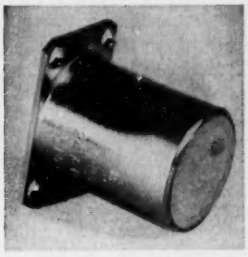
Circle 659 on Page 19

Miniature Solenoid

provides high-speed response

Model RS5178 miniature solenoid operates with a 10-lb load. Stroke

is 0.015 in., with start of motion occurring at a maximum of 6 millisec and stroke completed at less than 13 millisec from closing circuit. Unit requires 20 v dc at 78 F, and operates over ambient temperature range of −65 to 250 F. Solenoid has case diameter of 1.063 in., and rectangular flange with four mounting holes is an integral

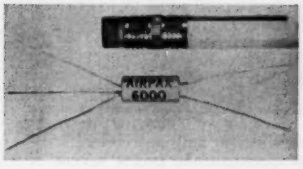


part of case. Telco Sales Div., Telecomputing Corp., 915 N. Citrus Ave., Los Angeles 38, Calif. L

Circle 660 on Page 19

Transistor Chopper

miniature unit has no moving parts



Miniature transistor chopper switches signal source to load at frequency rate of 0 to 100 kc per sec. Having no moving parts, unit operates under extremes of shock and vibration. Size permits use where space is at a premium, and weight is only 1 gram. Two types are available for temperature ranges of −40 to 60 C or −40 to 85 C: Type 6000 accommodates an input signal from a fraction of a mv up to 5 v; type 6010 extends upper signal level to 10 v. Unit can be driven by sine or square waves with peak-to-peak amplitudes of 1 to 18 v. Cambridge Div., Airpax Products Co., Jacktown Road, Cambridge, Md. C

Circle 661 on Page 19

Blower Units

for electronic cooling

MSA 4707 axial blower units are 6 in. in over-all diam, 4 in. long,

ACME CHAIN

NOW OFFERS
LARGEST SELECTION OF
FINISHED BORE SPROCKETS

99 Sizes
433 Different Bores

OFF THE SHELF SERVICE

- *Co... standard keyway and setscrew*
- *Ready ... allation . . . no reboring required*
- *Marked for easy identification and handling*
- *Immediate delivery from factory or distributor stocks*
- *A terrific saving in time and money — reduces down time — reduces maintenance cost — increases life of drives*

ACME finished sprockets are stocked in single widths from ⅜" to 1" pitch inclusive. 99 Sprocket tooth sizes with more than 433 different bores provide a wide selection range.

All finished bores are completely machined. Bores are accurately finished and are concentric to sprocket pitch and bottom diameters within A.S.A. standards.

Acme also carries a complete line of sprockets such as Grip-Master and Stock Sprockets.

CALL your local Acme Distributor, or Write Acme Chain Corporation Holyoke, Mass., Dept. 6-U.

Write for Bulletin No. 3 listing all sizes and prices.

Call ACME for Service

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

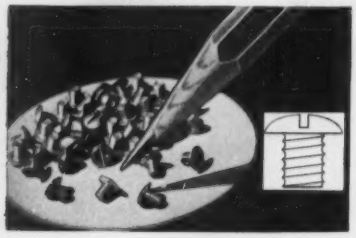
COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

Circle 507 on Page 19

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

Manufacturers of Cold Headed Fasteners Since 1888

OVER **5** TIMES THE RATE AT **45%** LESS COST



Another example of how Hubbell Cold Heading produces Better Parts at Faster Speeds, at Lower Cost

THE PART:
Special 1-64 Miniature Binding Screw

THE MATERIAL:
18-8 High Tensile Stainless Steel

THE METHOD:
Hubbell Cold Heading in place of screw machining

THE RESULT:

a. Production increased from original rate of 7000 pc. p.d. to cold heading rate of 40,000 pc. p.d.

b. Cost reduced 45%

c. Finer Quality—More Economical Production

1. Higher Tensile Strength
2. Cleaner, Stronger Threads
3. No Scrap Waste
4. No Separation from Chips

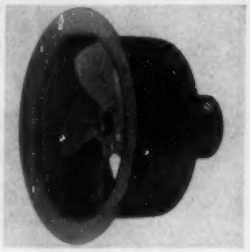
Hubbell Cold Heading may provide equally dramatic results for you. Whether it is presently cold headed or not, send blueprint of part or sample for analysis and estimate.

HARVEY HUBBELL, Inc. *Machine Screw Dept.*
Bridgeport 2, Connecticut

Kindly estimate on the enclosed
Sample (Blueprint). Quantity _____

Name _____
Title _____
Company _____
Address _____

Circle 508 on Page 19



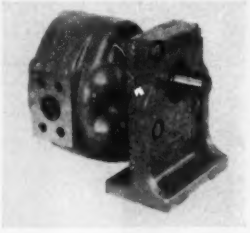
weigh 16 oz, and deliver from 50 to 160 cfm. Variations in unit size and air output can be furnished, and motor is either ac or dc. Applications include cooling electronic panels in computers, radio and television broadcast units, military electronic equipment, and other communications systems. **Air Impeller Div., Torrington Mfg. Co.**, Torrington, Conn. B

Circle 662 on Page 19

Fluid Motors

are rated from 90 to 210 lb-in. torque per 100 psi

Series 4MO gear-type fluid motors are available in both flange and foot mountings, with ports designed for SAE split-flange connections. They are rated from 90 to 210-



lb-in. torque per 100 psi, for operating pressure to 1000 psi. **Hydreco Div., New York Air Brake Co.**, Kalamazoo, Mich. H

Circle 663 on Page 19

DC Solenoid-Operated Valves

for pressures to 3000 psi

Shear-Seal direct solenoid-operated valves are available for operation on 12, 24, or 125 v dc. For pressures up to 3000 psi, they are furnished in standard or explosionproof solenoid housing. Valves are rated for oil and water pressures ranging from 0 to 250, 0 to 1500, and 0 to 3000 psi. Air valves are rated at 0 to 250, 0 to 1000, and 0 to 1500 psi. Valves are available in four-way,

SPECTROL PRECISION MECHANISMS

Black Boxes, Dry Powder, and Missile Making

It takes a lot of black boxes plus a good bit of dry powder to launch an occasional missile down at Cape Canaveral. Some of the black boxes contain Spectrol precision mechanisms, inline or otherwise, designed to control critical flight functions.

You may be interested in one of these units that we recently delivered to the missile people which has a number of industrial control applications outside this rather esoteric field. Known as a Function Programmer, this particular 3 x 4 x 5 inch package is used for the flight control of guided missiles. Inside the Spectrol black box is a precision mechanism consisting essentially of a permanent magnet dc motor which drives a Spectrol precision potentiometer and six rotary switches of special design developed by Spectrol. These units are interconnected by an appropriate gear train. In operation, the precise opening and closing of the rotary switches and the rotation of the Spectrol precision potentiometer control the flight altitude of the missile with respect to time.

As you can well imagine, devices of this type must be built to operate within precise specifications under severe environmental conditions. In addition to the usual MIL specs, this unit was built to withstand a 2000 cps vibration at 10 G's and a shock of 50 G's. The Spectrol precision mechanism not only operates after experiencing these conditions, but during them. Overall program timing accuracy is 3 percent.

Other applications for this little Spectrol package include checking a number functions sequentially in ground support equipment, programming machine tools, and controlling the order of operation in chemical and processing plants.

To accommodate the numerous countdowns involved in missile testing, this Spectrol precision mechanism runs twice as fast in the "reset" position as the "program" position.

More information, including a helpful 8 page booklet, on this and other Spectrol precision mechanisms designed for use as functional sub-assemblies is yours for the asking. Simply call your nearest Spectrol sales engineering representative or address Department 571.

4

SPECTROL

ELECTRONICS CORPORATION
Sales engineering representatives in principal cities.
1704 S. DEL MAR AVE., SAN GABRIEL, CALIFORNIA

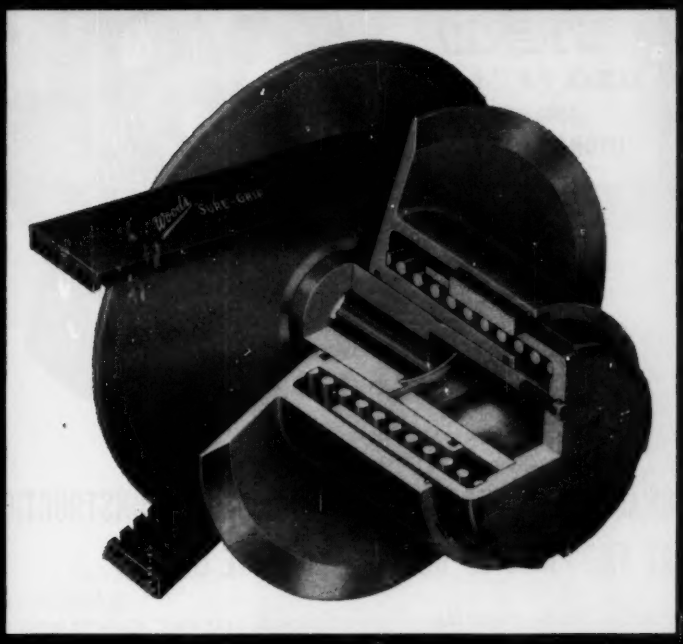
Circle 509 on Page 19

NEW WOOD'S VARIABLE SPEED PULLEYS ACTUALLY ELIMINATE FREEZING, STICKING

NEW
externally located,
resilient keys and

NEW
positive rotational
oil pumping
action give

NEW
freedom from
maintenance
and lubrication



Wood's new "MS" Motion Control Pulleys incorporate an entirely new concept of variable speed pulley design. Revolutionary features not only permit accurate and infinite speed adjustment, but completely eliminate fretting corrosion, freezing and sticking. There is no downtime . . . no periodic running through the speed range and, under normal operating conditions, the oil reservoir requires checking only twice a year. These startling advantages are made possible by two exclusive features . . .

NEW RESILIENT KEYS—There are no keys to obstruct the flow of oil around the bearing surfaces. Power is transmitted through a series of torsionally resilient rubber keys which are located outside the bearing surfaces between the sleeve cap and flange. These long-life, nylon-faced keys not only carry the belt torque but permit oil pumping action and assure even distribution of the load and equal transmission of power by both flanges.

NEW ROTATIONAL PUMPING ACTION—A continuous rotational pumping action of the flange hub on the sleeve completely re-oils the bearing surfaces with each rotation of the pulley. This positive lubrication system has resulted in shorter overall construction and less overhang.

New "MS" pulleys can be used with any type of straight face companion pulley. They are accurately balanced, operate in any position, fit both old and new NEMA frame motors. Get all of the facts. Write for bulletin 4101.

Woods

T. B. WOOD'S SONS COMPANY
CHAMBERSBURG, PENNSYLVANIA

ATLANTA • CAMBRIDGE • CHICAGO • CLEVELAND • DALLAS • NEWARK

Circle 510 on Page 19

GRADE A ACCURACY... PREMIUM GAUGE CONSTRUCTION AT THE PRICE OF GENERAL PURPOSE GAUGES...

Now you can buy hydraulic pressure gauges that are sturdier, more accurate, and have the specific quality features you need . . . yet cost you no more than you'd pay for general purpose gauges. These 5090 Series gauges are part of the new USG "A" Line, specifically designed to withstand the frequent shocks, pulsations, and mechanical vibrations—such as found in the operation of hydraulic presses, Diesel or oil field equipment, and the like.

MEET A.S.A. GRADE A STANDARDS—Available in sizes from 3½ to 12 inches, for pressures up to 10,000 psi, these gauges are guaranteed accurate within 1% of scale range for middle (working) half of scale—1½% for remainder.

EXTRA RUGGED CONSTRUCTION—For the severe service conditions found in hydraulic pressure measurements, the 5090 Series gauges embody such design points as:

a **Top quality, 403 stainless steel Bourdon tubes,** produced and quality-controlled in USG's own plant—your assurance of long, dependable service.

b **Extended life of movement,** through wide meshing gears, even under most severe conditions of pulsation and continuous service.

c **Protection from shock on movement,** through spring-loaded link, when pointer returns to zero with sudden release of pressure.

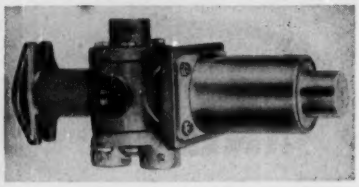
d **Sustained accuracy, reproducibility, and ease of maintenance** through use of USG's patented ARC-LOC movement (stainless steel pinion, nylon-faced stainless steel segment, and deep stainless steel bushings mounted in stainless steel plates.)

Find Your Nearest Distributor In The 'Yellow Pages'

PRICE, IT'S LOW!—You'll have to see the new Series 5090 gauge to believe that it's available without a premium price. Ask your U. S. Gauge distributor for a demonstration today, or write for a copy of new Catalog 305 which describes USG's complete line of industrial gauges.

UNITED STATES GAUGE
DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

USG



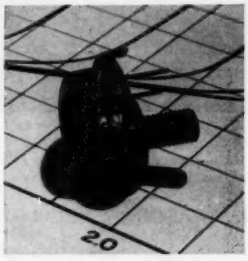
three-way, shut-off, and diverter flow patterns. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 664 on Page 19

Silicon Transistors

for switching and amplifier applications

Two high-power silicon transistors, rated at 2 and 5 amp, have a collector-to-emitter voltage range from 30 to 300 v and are capable of switching power up to 1 kw. Of NPN construction, units are designed for switching and amplifier applications. They have small case-to-junction temperatures up to 150 C. Each transistor is hermetically sealed in a welded stainless-steel case, designed for mounting



on an external heat sink by theaded stud. Over-all dimensions are 1¼ in. diam and 1 7/64 in. high. **Westinghouse Electric Corp.,** P. O. Box 2099, Pittsburgh 30, Pa. F

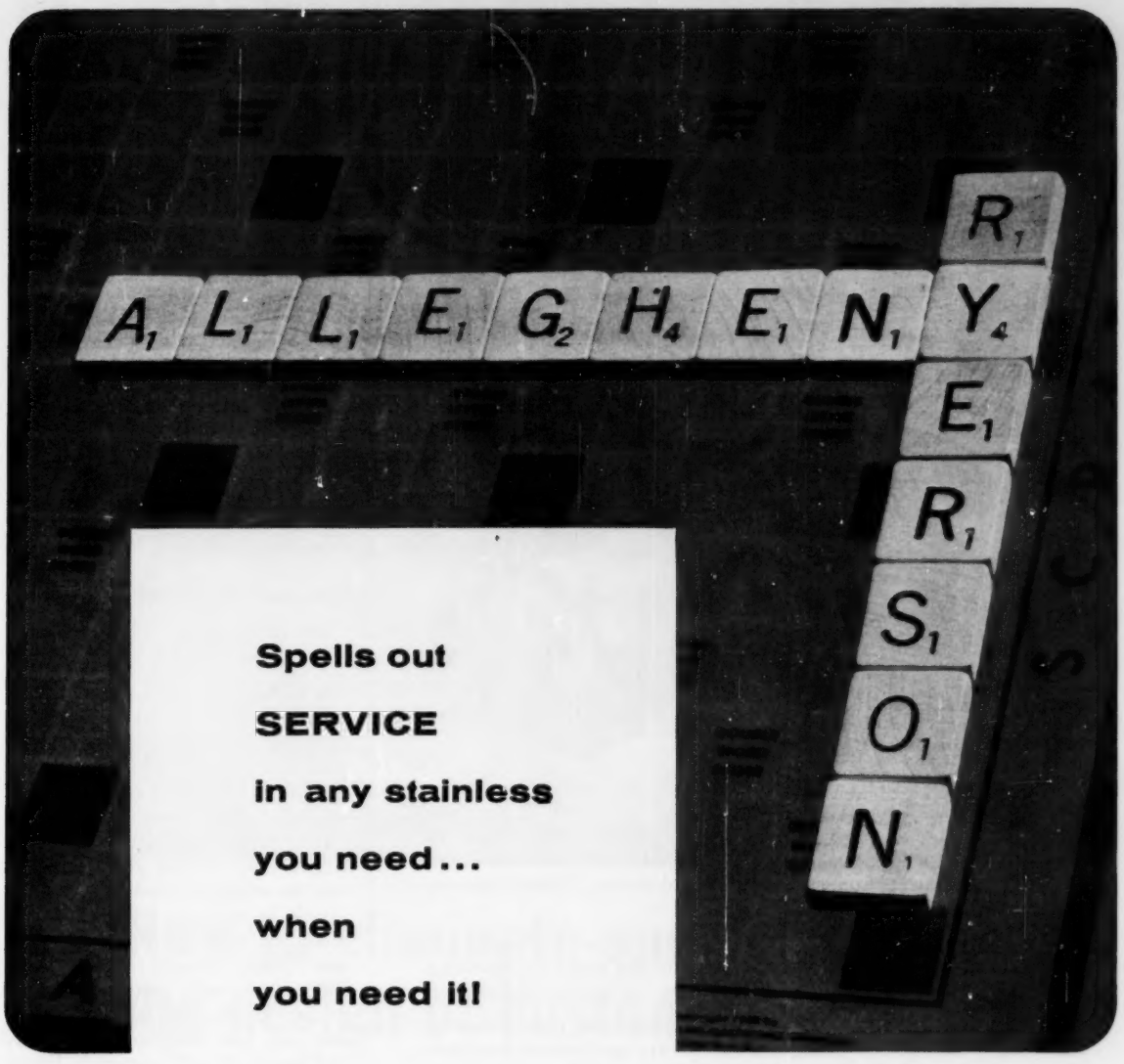
Circle 665 on Page 19

Transistorized Inverters

convert input voltages to outputs of different voltage levels

Four types of transistorized printed-circuit converter-inverters are static power sources which replace motor generator and vibrator-type devices for the conversion of ac or dc input voltages to ac and dc outputs of different voltage levels or frequencies. Units have wide application as aircraft radio, radar, and utility power supplies; missile instrumentation power supplies; mo-

Experience**—the extra alloy in **Allegheny Stainless



You can win only when you buy Allegheny Stainless from Ryerson. Two top names are teamed to give you quality stainless, the fastest way possible!

Allegheny Ludlum is the leading producer of stainless steels in all forms. Ryerson is recognized as the top steel service center. It's a team to bring you the best quality stainless, quick, when you need it.

Ryerson now stocks 2,351 shapes, sizes, finishes and alloys of Allegheny Stainless. It's the most complete line of stainless anywhere! And Ryerson takes the inventory cost from you, gives you as quick service as your own stockroom.

Whether your order is for Allegheny Stainless sheet, plates, bars, or whatever, Ryerson has it in stock. Trained salesmen and technicians to help in selecting or in fabricating are at your beck and call.

For top quality Allegheny Stainless from warehouse stocks, call Ryerson. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

WSW-7126

ALLEGHENY LUDLUM

for warehouse delivery of Allegheny Stainless, call RYERSON

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Why the heavy preference for Holtzer-Cabot motors? In a word—*reliability!* For they've proven themselves again and again in the most critical applications, dependability being a prime consideration in process control instruments, medical instruments and communication equipment. Shipments from stock on standard motors. Prompt delivery on special motors to your specifications.

R-24—Instrument Control Motors. Typical uses of this 2-phase induction motor are in servo systems, as the balancing motor in recording instruments, and in other applications requiring fast response and control.

R-25—Synchronous and Induction Capacitor Motors. Used in timing, recording, dictating, transcribing and small power applications. Available with standard speeds from ½ to 3600 R.P.M. Special designs available for extra high torque, extreme temperature conditions, dynamic braking and quick reversing.

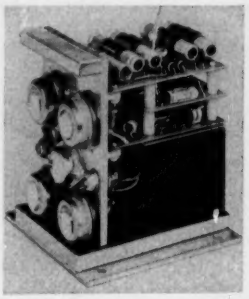
R-29—Synchronous and Induction Capacitor Motors. Ideal power source for high speed chart drive applications and other higher torque applications. Available in both 2-pole and 4-pole design, with H.P. range of 1/75 to 1/30.

For more information, write, or use Readers' Service Card.

Sales—Service Representatives in Principal Cities throughout the World

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston, Massachusetts

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems



bile and marine radio power supplies; remote radio telephone and telegraph; and portable power packs. Devices offer up to 5 w per cu in. output. Efficiency is 80 per cent for input voltages greater than 23 v. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 666 on Page 19

Encapsulated Motor

has motor stators cast in epoxy resin

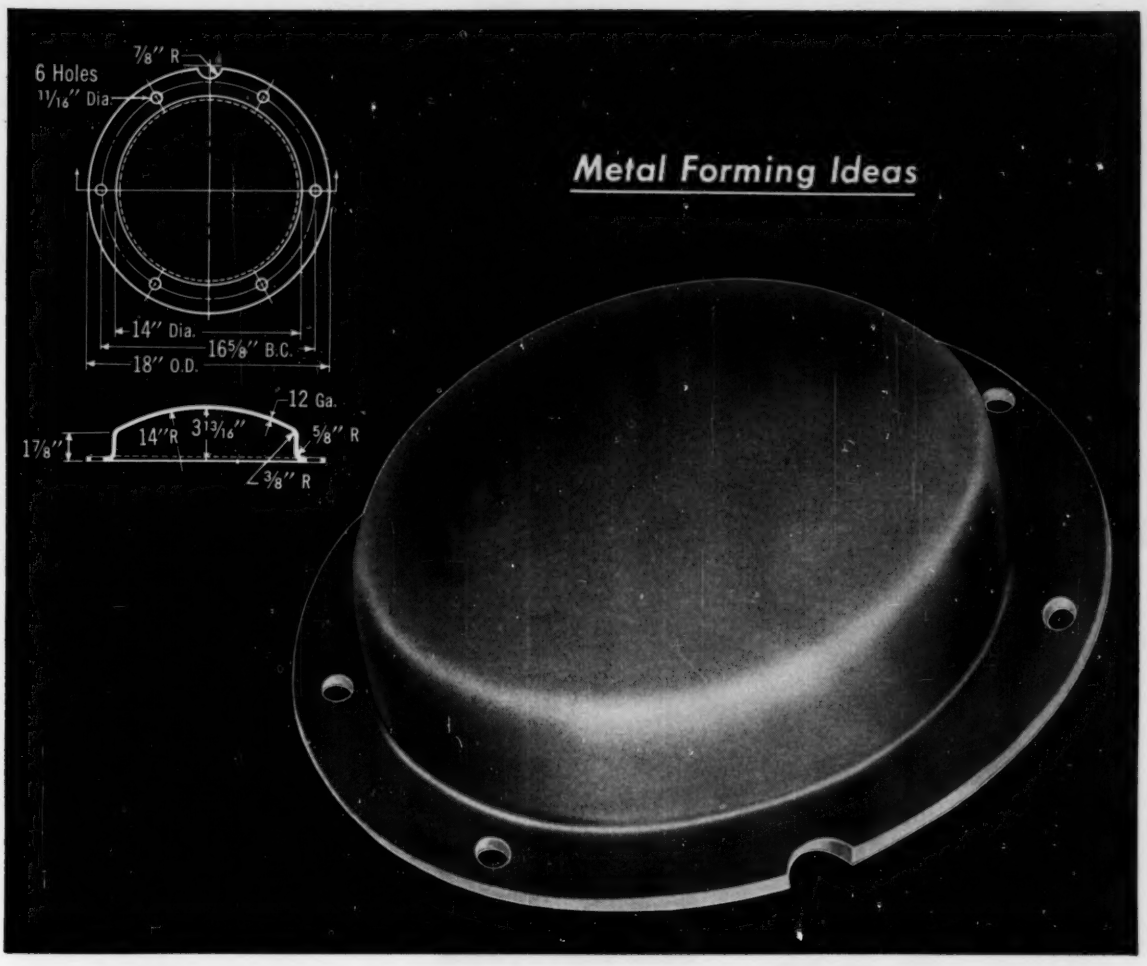
Applications for Super-Seal encapsulated motor are in systems where moisture or contaminated atmospheres could destroy effectiveness of conventional insulation system. End turns of motor-stator windings are completely enclosed in a hard, protective case, making them impervious to moisture and resistant to attack by solvents, oils, and commonly encountered chemicals. Resin also flows through slot portions, filling them with protection. Conductor, phase, and slot insulation are used, and these components are of Class A, B, or H materials. Epoxy now in use is suitable for Class B temperatures. Encapsulation is available in all integral-horsepower frame sizes in which random-wound coils are used. **Allis-Chalmers Mfg. Co.**, Milwaukee 1, Wis. K

Circle 667 on Page 19

Speed Reducers

for heavy-duty use provide speeds from 0 to 40 rpm

Zero-Max speed reducers provide a constant torque of 60 or 100 lb-in., delivered from ½ or ¾-hp motors, respectively. Units provide infinitely variable speed from 0 to 400 rpm. Speed controls permit accurate repeating of speeds and instant speed changes, whether



How to eliminate special tooling in the design of custom-formed parts

Custom stampings, formerly prohibitive cost-wise, can now be inexpensively formed through the use of existing dies from COMMERCIAL's "Die Bank" of almost 50,000 different forming die components.

A case in point: Wheel covers for American Coleman's aircraft towing tractor. They're important for the protection of the power transfer yokes in the tractor's four-wheel drive.

Stamping was first considered as the best method for forming them. The original low quantity involved and the amortization of $2,300 for special forming die costs, however, made the stamping unit costs impractical.

The covers were therefore first produced as machined, malleable iron castings at a cost of $8.49 per unit. A switch to hand spinning later reduced this cost to a still high $3.50 per cover.

American Coleman then discovered and investigated COMMERCIAL's "Die Bank". From 24 basic shapes ranging 4" to 72" in diameter and involving metal thickness from 20 gauge to ¾" —all available through the use of existing dies adapted to presses up to 2000 ton capacity—emerged an entirely practical and economical solution to the unit cost problem.

The design: A standard, dished, offset shape with vertical and horizontal flanges and dish radius equal to its dished diameter. The wheel cover of 12 gauge, stamped steel now provides complete protection, necessary yoke clearance and a pleasing appearance.

Best of all, by using an existing forming die from COMMERCIAL's "Die Bank", the actual tooling charge was only $80 for a simple modification of a single die component. And the unit cost was slashed to a practical $2.59.

The final result: A strong, lightweight wheel cover with a smooth surface for finishing which now completely and economically meets all requirements.

If your component requirement involves a custom-formed or unusual shape, and if the high cost of tooling prohibits its economical forming, the "Die Bank" service at COMMERCIAL may be just what you've been looking for. There's a quick way to find out. Just send along a blueprint, sketch or prototype of your part to Commercial Shearing & Stamping Company., Dept. S-2, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

Circle 514 on Page 19

Specify
BIJUR
AUTOMATIC LUBRICATORS

For
DESIGN, SERVICE AND RESEARCH
are part of every Bijur System

Consider Service—Bijur Field Engineers work hand in hand with machine builders to custom design a Bijur system which will amply meet the needs of the machine for automatic lubrication.

How you benefit—Whether you are a designer, purchasing agent, or plant engineer, you'll see substantial savings when you have Bijur Systems in the equipment you own and manufacture. Custom designed, Bijur Systems are easy to install, reduce down-time and repair bills, increase production, eliminate costly hand oiling. There's no chance for product spoilage due to over-lubrication, Bijur Systems deliver the right amount of metered oil to every bearing, *when it's needed.* Costly hand oiling is eliminated.

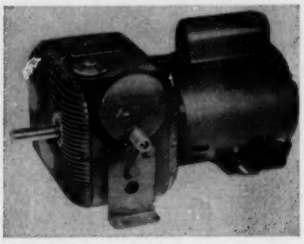
Write today for all the facts on how Bijur Systems can solve your lubricating problems.

BIJUR AUTOMATIC LUBRICATORS—STANDARD EQUIPMENT IN MANY INDUSTRIES
Machine Tools • Business Machines • Printing Machinery • Textile Machinery • Food Product Machines • Bottling Machines • Packaging Machines • Sheet Metal Machines • Plastic Fabricating Machinery • Glass Products Machinery • Wood-Working Machinery • Industrial Sewing Machines • Special Process Equipment

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

4348

units are running or not. Output shafts drive in either direction and are free-wheeling in direction of drive. The heavy-duty units are available with or without motors. Basic motor is an open-frame, drip-



proof, 60-cycle, 115/230-v, single-phase, capacitator-start unit. Totally enclosed, explosionproof, double-shaft, and other motors are also available. **Revco Inc.**, 1900 S. Lyndale Ave., Minneapolis 5, Minn. J

Circle 668 on Page 19

Precision Gear Heads

for use with Size 11 servo motors

Size 11 precision gear heads are designed for use in conjunction with standard BuOrd Size 11 servo motors and, using adapters, with other than Size 11 motors and systems. They provide long, accurate life in

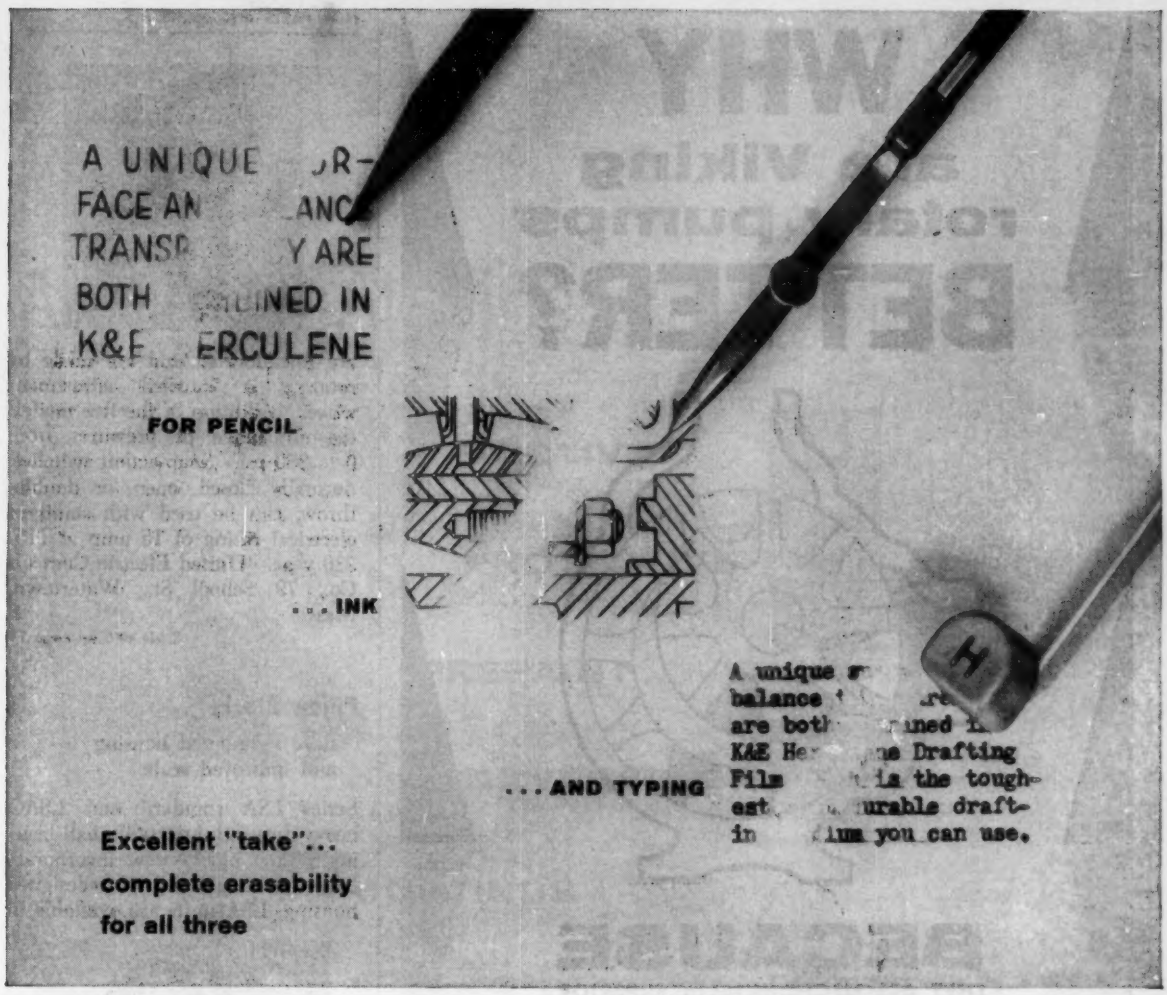
high and low-temperature applications, and withstand environmental tests covered by MIL-E-5272A. **Fae Instrument Corp.**, 42-61 Hunter St., Long Island City 1, N. Y. D

Circle 669 on Page 19

Pressure Controls

are equipped with phosphor-bronze bellows

J40 lightweight pressure controls are available in five models suitable for air, gas, or liquid pressures. Units incorporate phosphor-bronze bellows, permitting differentials as close as 12±oz. Pressure settings



Now K&E provides the ultimate "3-way" surface for super-tough HERCULENE™ Drafting Film

Only K&E Herculene Drafting Film has a surface perfectly engineered for pencil, ink and typing . . . plus the extreme toughness and durability of a DuPont "Mylar®" film base. You get the absolute assurance of superior "take". And Herculene erases easily and quickly without the need for erasing or correcting fluids.

Virtually indestructible, Herculene is so tough you can hardly tear it. It can't be damaged by moisture. And it's permanent . . . your drawings are resistant to damage by aging or handling.

Herculene has "balanced" transparency . . . just the right combination of high actinic transparency for reproduction with essential visual opacity for drafting. You get sharp, legible reproductions at high machine speeds. And you can make prints from a Herculene Drawing indefinitely without its yellowing or tearing, cracking or becoming brittle.

Herculene is economical too . . . now costs *less* than cloth. Prove these facts for yourself by writing today for a free sample. Just clip and mail the coupon below.

KEUFFEL & ESSER CO., Dept. MD-1 Hoboken, N. J.

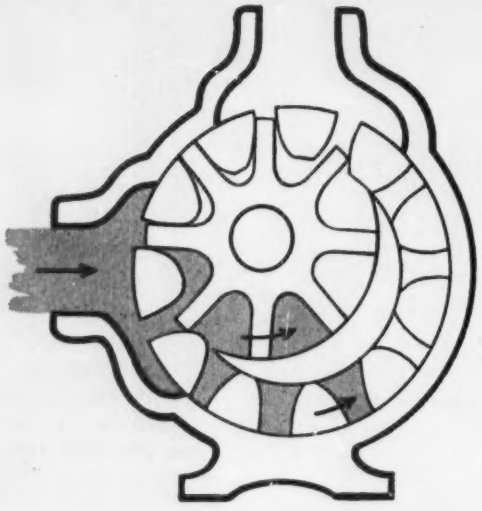
I want to see a sample of the new K&E Herculene.

Name & Title: _____

Company & Address: _____

_____

WHY are Viking rotary pumps BETTER?



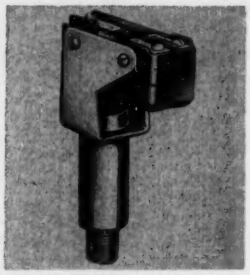
BECAUSE
THEY ARE MECHANICALLY SUPERIOR

The Viking "gear-within-a-gear" pumping principle makes liquids flow into and through the pump, changing direction ever so slightly until liquids are trapped. This action cuts turbulence, foaming, cavitation and power consumption to a minimum. As a result, liquids are delivered in a smooth, positive flow . . . free of aeration.

TESTED

In test after test the superiority of Viking's pumping principle has been proved over other rotary pump action . . . and even more pronounced when handling fluids of 750 SSU and thicker. Learn the complete story on Viking rotary pumps. Send for free catalog 59SH.

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada it's "ROTO-KING" Pumps
See Our Catalog in Sweet's Product Design File.



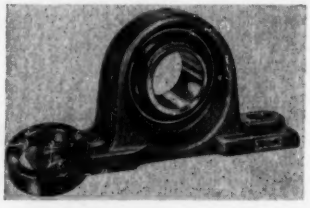
are uncalibrated and are made by rotating a knurled adjustment wheel. Addition of the five models extends range of pressures from 0 to 350 psi. Snap-action switches, normally closed, open, or double-throw, can be used with standard electrical rating of 15 amp at 115-230 v ac. **United Electric Controls Co.**, 79 School St., Watertown, Mass. B

Circle 670 on Page 19

Pillow Blocks

have redesigned housing and improved seals

Series LSA standard and LSAO heavy-duty relubricatable ball-bearing pillow blocks now incorporate improved seals and a redesigned housing. LSA units are available in



sizes through 2 15/16 in., and LSAO through 3 15/16 in. **Fafnir Bearing Co.**, 37 Booth St., New Britain, Conn. B

Circle 671 on Page 19

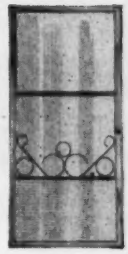
Automatic Air Booster

is available in ratios from 1.5:1 to 6.25:1

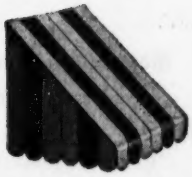
Series AB air booster boosts airline pressure automatically in surge tanks and die cushions, maintains constant air pressure on press clutches, furnishes high-pressure air for testing refrigeration devices, and on any other application where airline pressure must be boosted. Pressure regulator, filter, and lubricator are furnished with booster. Unit is

Amchem Alodine...

EFFECTIVE



PROTECTIVE



PREPAINT

CONVERSION

COATINGS

FOR ALUMINUM

If you fabricate aluminum products—painted or unpainted—Amchem Alodine can provide you with an effective and protective chemical conversion coating process of remarkable characteristics.

The Amchem Alodine process forms an amorphous coating which becomes an integral part of the metal, enhances the natural corrosion resistance of the aluminum and provides an excellent bond for paint.

Alodine's simplicity, speed and economy as a prepaint treatment has gained widespread commercial acceptance in a wide variety of product applications.

Beyond product, Amchem provides the metalworking industry a complete service—processes, technical and engineering assistance, installation and instruction service—for corrosion protection, paint bonding, or other metalworking problems.

Write for complete information contained in Bulletin 1424A describing the uses of Amchem Alodine, as well as other literature pertinent to Amchem chemical conversion processes for the metalworking industry.

AMCHEM ALODINE

Amchem Alodine is another chemical development of **Amchem Products, Inc.**, Ambler, Pa. • Formerly American Chemical Paint Company Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont./Amchem and Alodine are registered trademarks of Amchem Products, Inc.

FREE reprints from MACHINE DESIGN

Limited supplies of the following reprints of articles which have appeared in MACHINE DESIGN are still available at no cost. Circle the ones you want on the order form below and mail to Reader Service, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

1 Basic Factors in AIR-CIRCUIT DESIGN by Kenneth A. Merz, June 28, 1956 (10 pages)

2 How to Analyze ROLLING-CONTACT MECHANISMS for Acceleration Characteristics by Ching-u Ip, I. E. Morse Jr. and R. T. Hinkle, July 26, 1956 (3 pages)

3 Principles and Design Uses for ANALOG SIMULATORS by J. N. Macduff, August 9, 1956 (6 pages)

4 Mechanics of Applying ELECTRIC MOTORS by W. R. Harris, November 28, 1957 (6 pages)

5 A Simplified Numerical Method for FITTING EQUATIONS TO EXPERIMENTAL DATA by A. Bruce Cox, January 24, 1957 (7 pages)

6 BASIC CAM SYSTEMS by Harold A. Rothbart, May 31, 1956 (4 pages)

7 Design Equations and Nomographs for Self-Energizing Types of SPRING CLUTCHES by Joseph Kaplan and Donald Marshall, April 19, 1956 (6 pages)

8 Conic Linkages Offer Design Possibilities for 3-D MECHANISMS by F. R. Erskine Crossley, September 1955 (11 pages)

9 Designing BUILT-IN LIGHTING for Machines by Robert C. Rodgers, February 1954 (16 pages)

10 A Basic Outline of PHYSICAL MECHANICS by George H. Logan, April 5, 1956 (8 pages)

11 MOTOR CIRCUIT PROTECTION by G. W. Heumann, June 1954 (16 pages)

12 Nomographs Speed Design of CANTILEVER BEAMS Subjected to Concentrated Loads by Donald Marshall, January 26, 1956 (4 pages)

13 Fastening and Joining CARBIDES by W. L. Kennicott, March 22, 1956 (12 pages)

Send reprints without charge as circled below:

1 2 3 4 5 6 7

8 9 10 11 12 13

Penton Building
Cleveland 13, O.

NAME TITLE

COMPANY

ADDRESS

CITY ZONE STATE

available in ratios from 1.5:1 to 6.25:1. Six mounting styles, including foot, side, and end-lug mount, are offered. **Lynair Inc.**, Dept. A-B, 3100 E. Michigan Ave., Jackson, Mich. H

Circle 672 on Page 19

Magnesium Sheet Alloy

requires no stress relief after welding

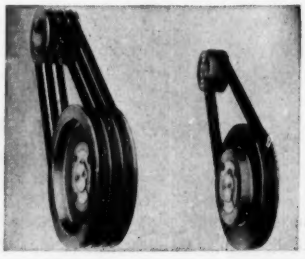
ZE10A magnesium sheet and plate alloy contains zinc and rare-earth metal as alloying constituents. Elimination of need for stress relief after welding makes material useful in very large structures and in field repair operations where stress relief is difficult to apply. Typical mechanical properties in H24 temper (strain hardened, then partially annealed) include: Tensile strength, 38,000 psi; tensile yield, 28,000 psi; and compressive yield, 26,000 psi. Alloy is also furnished fully annealed. **Dow Chemical Co.**, Midland, Mich. H

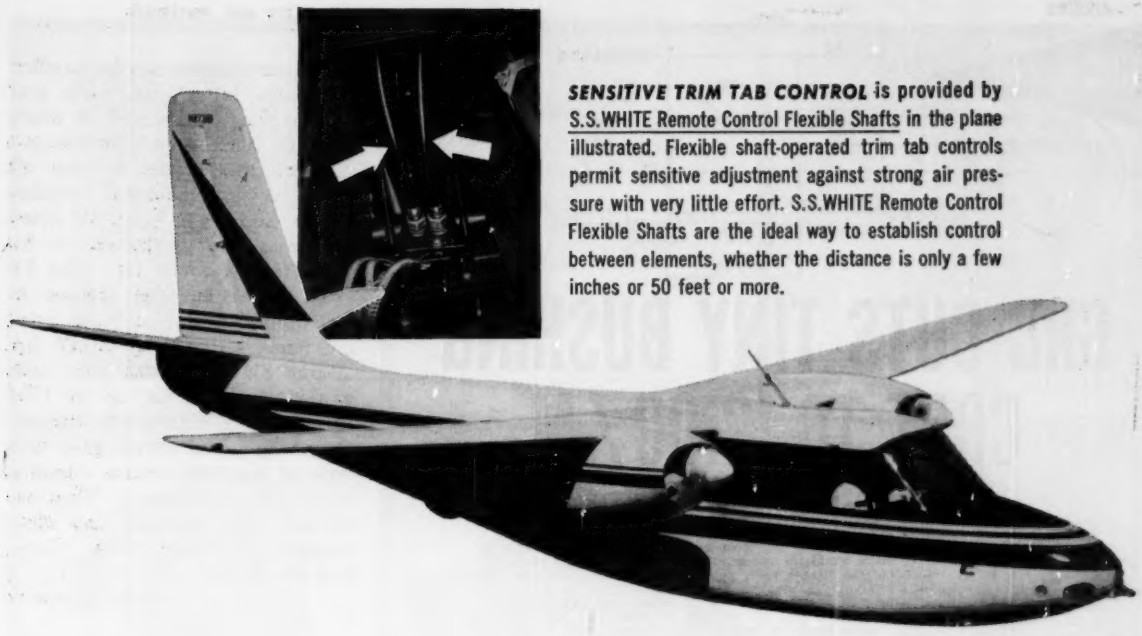
Circle 673 on Page 19

V-Belt Drives

provide savings in space, weight, cost

Dyna-V drives (right) feature smaller and lighter sheaves and V-belts of higher capacity at lower cost than previous units. Majority





SENSITIVE TRIM TAB CONTROL is provided by S.S.WHITE Remote Control Flexible Shafts in the plane illustrated. Flexible shaft-operated trim tab controls permit sensitive adjustment against strong air pressure with very little effort. S.S.WHITE Remote Control Flexible Shafts are the ideal way to establish control between elements, whether the distance is only a few inches or 50 feet or more.

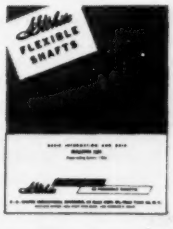
S.S.White

CONTROL AND DRIVE IDEAS FOR ENGINEERS

Tips on Better Designing with Flexible Shafts

FLEXIBLE COUPLING SHAFT eliminates need for alignment and does not transmit vibration in this variable frequency crystal holder. The coupling shaft is connected to the crystal holder and also to the dial with a set screw, making it easy to assemble the shaft after holder and dial are mounted. S.S.WHITE Coupling Shafts are available for either remote control or power drive.

LIGHTER WEIGHT AND SIMPLER DESIGN are achieved in this brush cutter by the use of an S.S.WHITE Power Drive Flexible Shaft. Cumbersome and troublesome gears are eliminated. Better balance is gained, since the weight of the motor, carried by the operator's harness, is located to give the unit perfect balance for finger-tip control. The unit can be swung easily into any position, high or low. The flexible shaft gives fully dependable service.

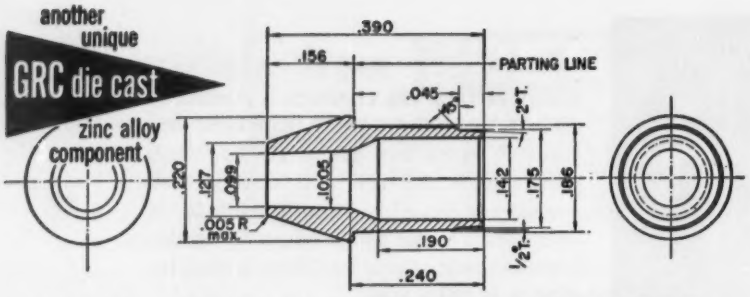


WHETHER YOU NEED specially engineered, custom flexible shafts, or standard off-the-shelf shafts, rely on S.S.WHITE. For information on standard shafts, write for Bulletin 5801; for custom-designed shafts, ask for Bulletin 5601.

S.S.White — IN FLEXIBLE SHAFTS

S.S.WHITE INDUSTRIAL DIVISION, 10 East 40th Street, New York 16, New York
Western Office: 1839 West Pico Blvd., Los Angeles, Calif. (Dept. 4)

another unique GRC die cast zinc alloy component



GRC CUTS TINY BUSHING COST TO $2.00/M

Die cast by GRC in zinc alloy in a single automatic operation, this former screw machine part for a ball point pen, now costs little more than $2.00 per thousand in lots of a million. Each bushing is uniform, clean and accurate—no cut-off marks, no burrs, no secondary trimming and no scrap loss. Typical of the production economies and wide design latitude which GRC's exclusive patented methods have made possible on parts "no bigger than your thumbnail." (Maximum size is 1¾" long, ⅛ oz.; no size too small).

Simple or complex, let GRC's unique techniques go to work for you . . . on tiny die cast *and plastic molded* parts made to order . . . on their wide variety of standard parts available in stock—die cast wing and round head thumb nuts and screws, cap nuts, molded nylon screws, gears and pinions—you'll be glad you did.

Write, wire, phone TODAY for bulletins, spec sheets and prices. Send prints or specs for quotation.

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-8600

Circle 522 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency. **$1.00 per copy**

A MACHINE DESIGN REPRINT

ORDER FROM: Machine Design Reader Service

Penton Building, Cleveland 13, Ohio

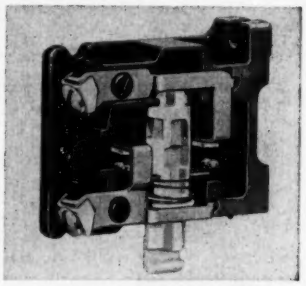
(Remittance or Company Purchase Order must be enclosed with order)

of industrial drives can be handled with belts only ⅜ in. wide, and sheaves that are reduced in width and OD. Drives are offered in two standard groove sizes to meet all except largest industrial requirements. Sheaves in ⅜-in. 3V series, with from 1 to 10 grooves, are for drives from 1 to 50 hp. The 5V ⅝-in. series includes sheaves to take from three to ten ⅝-in. belts, and handles drives up to 200 hp. Custom 8V series with 1-in. belts is also available for up to 1500 hp. Belts are particularly immune to stretching, and are designed with crowned top and concave sidewalls for maximum efficiency. They are oil and heat resistant, and static conducting. **Dodge Mfg. Corp.**, Mishawaka, Ind. J

Circle 674 on Page 19

Contact Poles

individual units have noble-metal contacts



One or more poles or rugged industrial-control relays can be used in electronic and instrumentation circuits by using new individual poles with noble-metal contacts. Use enables grouping of electronic and standard control circuits for actuation by the same magnet. Poles have contact tips of palladium-ruthenium alloy, a hard material with high melting point which is highly resistant to corrosion and tarnish and does not form a stable oxide. Available in normally open and normally closed types, poles can be used in high-impedance and low-voltage circuits which produce little or no arcing. They are recommended for use in circuits of up to 600 v, drawing 0.5 va or less. Poles are mounted in individual melamine blocks. **Clark Controller Co.**, 1146 E. 152nd St., Cleveland 10, Ohio. F

Circle 675 on Page 19

every aspect of Ward Leonard bulletin "HR" relays is designed for maximum reliability . . . these are components you can buy, install and then forget

Ward Leonard "HR" relays are engineered for industrial and electronic applications requiring: ultra-long life, high speed, high reliability, compactness and versatility.

Consider the powerful solenoids, just one of the features shown above. Every HR relay, AC or DC, is equipped with a powerful solenoid to assure fast, consistent, long-life operation so essential in the circuitry of any high reliability relay. The "E-I" laminated magnet armature is free-floating and self-aligning to minimize noise level. DC solenoids feature exceptionally fast operation. Nylon armature guides minimize operational friction. All AC and DC power plants are readily interchangeable.

2 to 8 pole "HR" relays are but one of five W/L lines of industrial power relays . . . all designed with emphasis on reliability. Write for bulletin 4470. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N.Y. G-1

WARD LEONARD
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

LIVE BETTER...*Electrically*

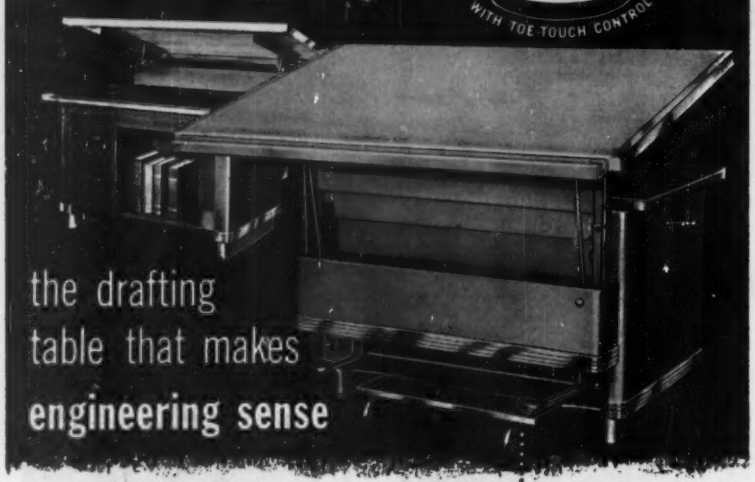
Result-Engineered Controls Since 1892

RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

Circle 523 on Page 19

NEW STACOR-MATIC

WITH TOE-TOUCH CONTROL



the drafting table that makes engineering sense

- Increases productivity, efficiency
- Saves man-hour costs
- Reduces waste motion
- A complete work-station in one unit.

Get all the facts—send for illustrated Bulletin 603 and complete NEW Stacor catalog

STACOR EQUIPMENT CO.
273 Emmet St., Newark 5, N. J. • Bigelow 2-6600

Circle 524 on Page 19

Design Guide to

Adjustable-Speed Drives

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

(Remittance or Company Purchase Order must be enclosed with order.)

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio

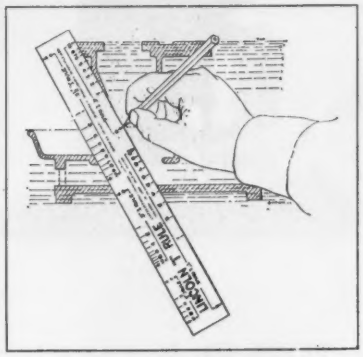
ENGINEERING DEPARTMENT

EQUIPMENT

Moment-of-Inertia Rule

for use with irregular sections

New moment-of-inertia rule simplifies determination of moment of inertia of irregular sections. Using the rule, an irregular section is converted into simple rectangles. Moment of inertia of each rectangle is found by $I = wh^3/3$ formula, and moments are totaled to obtain moment of inertia of original



irregular section. Accuracy is within ½ per cent. **Lincoln Electric Co.**, 22801 St. Clair Ave., Cleveland 17, Ohio. F

Circle 676 on Page 19

Speed-Changer Kit

provides 29 different ratios

Bantam speed-changer kit permits rapid assembly of a complete speed changer in any one of 29 ratios from 1:1 to 44:1. Housings, bearings, gears, and shafts can be used repeatedly for assembling different ratios. Gears are 48-pitch, 20-deg pressure-angle spur gears of case-hardened steel. Input and output shafts run in two ball bearings on each shaft, and countershafts run in ground needle bearings. Torque is 130 oz-in. maximum at low-speed shaft, speed is 10,000 rpm maximum at high-speed shaft, and horsepower is 0.1 hp maximum at low-speed shaft. Lubricant, wrench, instructions, and a gear gage, as well as

NEW Maxitorq 9000 SERIES*

ELECTRIC CLUTCHES or BRAKES

Featuring these

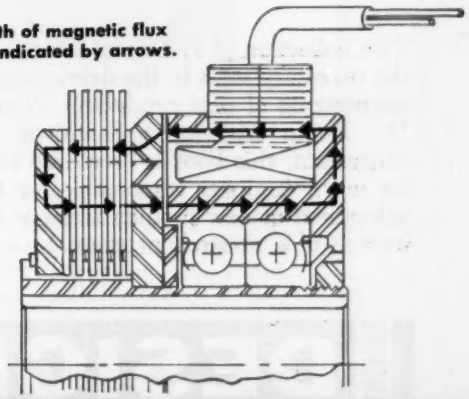
Advantages:

- **Compact and Simple Design**
- **Built to American Standards**
- **Stationary Coil**
- **No Slip Rings or Brushes**
- **Self-Adjusting—Easily Installed**
- **Drag-free Floating Neutral**
- **No Stressed Levers or Parts**
- **Use as Brake or Clutch**
- **Standard Flange Cups Available**

*Patent applied for.

OPERATION INDUCED ENTIRELY BY *Magnetic Flux*

The new Maxitorq #9000 Series Electric Clutch is a compact, self-contained unit with operation dependent upon induced magnetic flux. As shown in the drawing below, this new Maxitorq Clutch consists essentially of a sealed magnetic coil and housing arrangement actuating multiple discs which also act as the flux path. Because the coil housing, supported on anti-friction bearings, is stationary, troublesome brush and slip ring construction is eliminated. When energized, the entire assembly consisting of pressure plate, inner and outer discs, and buttress plate is locked together by the magnetic force passing through it. When de-energized, Maxitorq separator springs instantly separate the discs creating air gaps which help to break up residual magnetism. Compactness, fast response, and flexibility of control make the #9000 Series clutch or brake ideally suited for a wide range of applications.



Path of magnetic flux is indicated by arrows.

Write, phone, or wire Dept. MD now for Bulletin 90 describing the most advanced design of electric clutches or brakes available today.

Let's talk MAXITORQ

THE CARLYLE JOHNSON MACHINE CO. • MANCHESTER, CONN.

At last!

A STEP-BY-STEP GUIDE TO . . .

This 102 page volume includes practical data on:

- Measuring company needs in new-product development
- Developing and finding new-product ideas
- Evaluating new-product potentials
- Organizing engineering and research for product development
- Measuring progress in product performance

MACHINE DESIGN

Reader Service. Penton Building Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order.)

Send me ____ copies of
Planning New Products @ $3.00 each

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____

(Add 3% to orders for delivery in Ohio to cover State Sales Tax.)

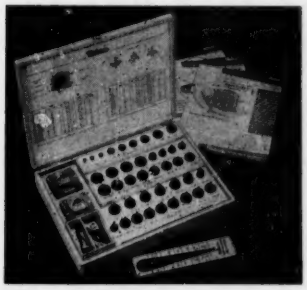
This collection of 17 helpful articles details the necessary steps to the development and engineering of new products. Written by Dr. Philip Marvin, well-known market consultant, this book is "required reading" for *every* engineer responsible for the development of new product ideas or the operation of a research program.

A

MACHINE DESIGN

REPRINT

←MAIL TODAY



gears, shafts, and housings, are contained in a durable carrying case. **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo. K

Circle 677 on Page 19

Adding-Subtracting Machine

pocket-sized unit is for feet, inches, and fractions

Addfeet Junior, which measures 6¼ x 1½ in., weighs just 3 oz including leather case. Unit adds, subtracts, and converts feet, inches, and fractions as low as eighths. Capacity is 9999 ft, or 11⅞ in. Machine has separate addition and subtraction columns with clear disposition of figures. **Alexander Drafting Equipment Co.**, Dept. 123, 642 N. Chester Ave., Pasadena, Calif. L

Circle 678 on Page 19

All-Steel File

accommodates large items which cannot be folded

Flatfile all-steel file is a four-shelf unit for filing large plans, tracings, maps, and blueprints, of sizes up to 33 x 42 in. which cannot be folded. Lock-equipped disappearing door provides unhampered access. Unit stacks in multiples to conserve floor space. Desk-high leg base places a single section at easy working height; low base is also available. **Ross-Martin Co.**, P. O. Box 800, Tulsa 1, Okla. I

Circle 679 on Page 19

MicroRold®

stainless steel soars with ATLAS ICBM on first full range flight!

U. S. missile program one step nearer to complete operational capability.

On the evening of November 28, 1958, a 100-ton ATLAS lifted from its pad at Cape Canaveral and arched majestically into the heavens. 30 minutes later its nose cone shot into the Atlantic, marking the first successful completion of its fully-programmed distance of 6300 statute miles.

The main part of the ATLAS structure is literally a huge fuel tank, the skin of which is thin gauge MicroRold stainless steel. Important factors in selection of stainless steel for the outer skin of the ATLAS are—great strength at both high and low temperatures, resistance to corrosive exotic fuels and good workability.

The stainless skin, supplied exclusively by Washington Steel, requires extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

NOW IN ORBIT!

4½ ton third stage
118 to 625 mile altitude
December 18, 1958

WASHINGTON STEEL CORPORATION

I-E WOODLAND & GRIFFITH AVENUES

WASHINGTON, PA.

Circle 527 on Page 19

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

THE ENGINEER'S

Library

Recent Books

How To Design and Specify Printed Circuits. *92 pages, 6 by 9 in., clothbound; published by and available from Institute of Printed Circuits, 27 East Monroe St., Chicago 3, Ill.; $5.00 per copy.*

This manual presents the collective experiences of firms which manufacture printed-wiring devices. Methods of design, specification, and tolerance application are recommended.

Elementary Matrix Algebra. *By Franz E. Hohn, associate professor of mathematics, University of Illinois; 305 pages, 6 by 9¼ in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN; *$10.00 per copy postpaid.*

Fundamental ideas and methods of handling rectangular arrays of numbers or functions are presented with a collection of exercises suggested by engineering applications. Transformation of linear equations and polynomials into matrix forms and the basic rules for addition, subtraction, and multiplication of matrices are illustrated. Properties of determinants are discussed and developed. Greek notations for sums and products and the algebra of complex numbers are reviewed in the appendix.

BICERA: A Handbook on Torsional Vibration. *Edited by E. J. Nestorides for the British Internal Combustion Engine Research Association; 664 pages, 6 by 9 in., clothbound; published by New York: Cambridge University Press, 32 East 57th St., New York 22, N. Y.; available from* MACHINE DESIGN; *$19.50 per copy postpaid.*

Work done by BICERA laboratories and its member firms supplies the basis for an engineering approach to the problems of torsional vibration presented in this handbook. Each method of solution contains recommended formulas, graphical procedures, numerical examples, and

Advanced aluminum rotor casting process prevents air bubbles and shrinkage that cause stress and trouble!

For over a third of a century Baldor has pioneered many new ways to build electric motors better . . . for less money. Baldor's aluminum-cast rotor in the new NEMA frames is a good example.

This careful, precision method of casting produces a rugged, stress-free rotor without air bubbles and shrinkage cavities that can cause broken bars . . . loss of power . . . and motor damage! New design refinements have also improved torque characteristics while lowering the noise level.

Engineering extras like this (without extra cost) are your guarantee that you can specify Baldor Streamcooled Motors with complete confidence.

FOR MORE INFORMATION ON THE COMPLETE LINE OF BALDOR MOTORS, WRITE . . .

BALDOR

ELECTRIC COMPANY

4349 Duncan Avenue • St. Louis 10, Missouri

Over 500 Authorized Sales & Service Distributors in U. S. A.

District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton • Des Moines • Detroit • Litchfield, Conn. Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • Kansas City, Mo. Oakland • Philadelphia • Portland, Ore. • Syracuse.

Circle 529 on Page 19

36

Complete reprints of major articles now available from

MACHINE DESIGN

USE THIS FORM TO ORDER YOUR COPIES TODAY!

Number Copies		Price Per Copy
____	DIRECTORY OF MATERIALS—18th Edition	$1.00
____	PRODUCTION CHARACTERISTICS OF ENGINEERING METALS	1.00
____	DESIGN MANUAL ON ADHESIVES	1.00
____	NONMETALLIC GASKETS	1.00
____	ADJUSTABLE SPEED DRIVES (Electrical, Mechanical, Hydraulic	2.00
____	ADJUSTABLE-SPEED ELECTRIC-MOTOR DRIVES	1.00
____	MECHANICAL ADJUSTABLE-SPEED DRIVES	1.00
____	SPEED REDUCERS AND GEARMOTORS	1.00
____	INTERNAL COMBUSTION ENGINES	1.00
____	WHY MACHINE PARTS FAIL	1.00
____	STRESS ANALYSIS IN DESIGN	1.00
____	DIMENSION CONTROL IN DESIGN	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. I	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. II	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. III	1.00
____	PRECISION GEARING	1.00
____	QUALITY CONTROL METHODS	1.00
____	MULTPLE CIRCUIT SWITCHES	1.00
____	ELECTRICAL CONNECTORS	1.00
____	TRANSACTIONS OF THE FIRST CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE SECOND CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE THIRD CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE FOURTH CONFERENCE ON MECHANISMS	2.00
____	MECHANISMS FOR INTERMITTENT MOTION	1.00
____	POLYDYNE CAM DESIGN	1.00
____	ENGINEERING MANAGEMENT	2.00
____	MEN AND MACHINES	1.00
____	DESIGNING WITH TEFLON	1.00
____	DYNAMIC SEALS AND PACKINGS	1.00
____	MECHANICS OF VEHICLES	2.00
____	1956 DATA SHEETS	2.00
____	1957 DATA SHEETS	2.00
____	TIPS AND TECHNIQUES—VOL. I (Drafting Aids)	1.00
____	TIPS AND TECHNIQUES—VOL. II (Engineering Aids)	1.00
____	PLANNING NEW PRODUCTS	3.00
____	DESIGN GUIDE FLEXIBLE COUPLINGS	1.00

MACHINE DESIGN

Reader Service
Penton Building
Cleveland 13, Ohio

TOTAL COPIES _____

TOTAL ORDER $ _____

Remittance or Company Purchase Order must be enclosed with order.

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

(Add 3% to orders in Ohio to cover State Sales Tax)

tabulated values followed by the limitations of each method and its mathematical derivation. Also included are descriptions of test procedures, rigs and instrumentation, precautions against possible sources of error, and the accuracy to be expected of test results.

Monograph No. 6—Ten Steps into Space. *202 pages, 6⅛ by 9½ in., paperbound; published by and available from Journal of The Franklin Institute, 20th and the Parkway, Philadelphia 3, Pa.; $4.00 per copy.*

This monograph contains a series of ten semitechnical lectures on astronautics presented by experts on space travel. Covered are the history of space travel and its future, rockets and rocket fuels, satellite instrumentation and orbits, space medicine, and space navigation and investigation.

Government Publications

Proceedings of the Third Sagamore Ordnance Materials Research Conference: Materials Evaluation in Relation to Component Behavior, PB 131783. *622 pages, 8 by 10½ in., paperbound; published by and available from Office of Technical Services, U. S. Department of Commerce, Washington, D. C.; $8.00 per copy.*

This report contains 21 technical papers presented by metallurgical experts from industry, universities, and the government at a meeting sponsored by the U. S. Army Ordnance Corps.

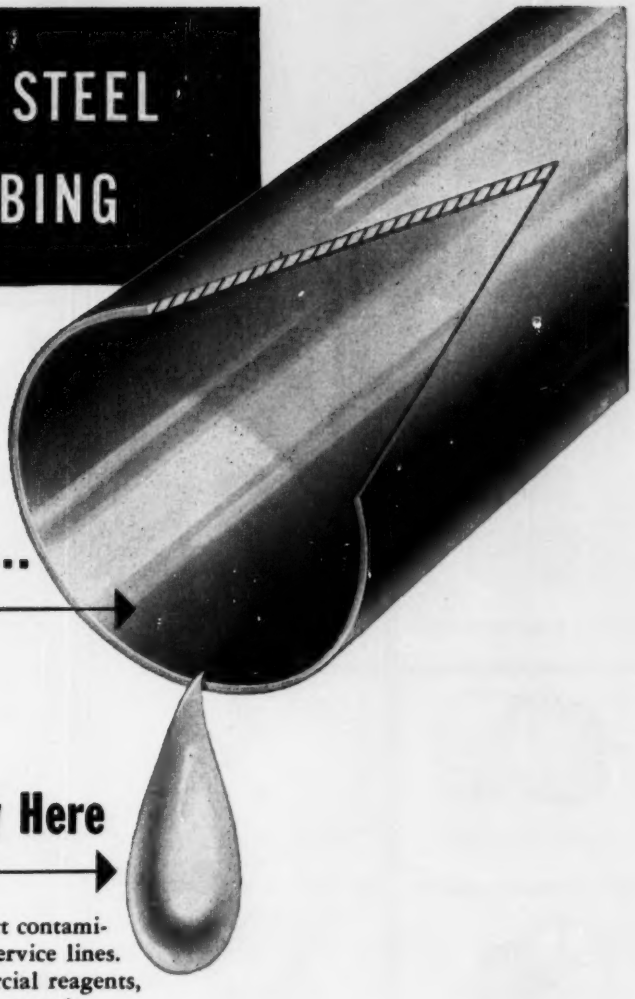
The presentations emphasize the advancements in testing techniques and, particularly, the design of more realistic tests. Also included are papers on stress corrosion, hydrogen embrittlement, and the evaluation of weldments.

NASA Research Memorandums. *Publications are 7¾ by 10¼ in., paperbound and side-stapled; available from Division of Research Information, National Aeronautics and Space Administration, 1520 H St. N.W., Washington 25, D. C.*

The following memo is available:

Memo 11-21-58W. Effect of Rest Periods on Fatigue of High-Purity Aluminum. *By J. W. Berry, J. Lemaitre, and S. R. Valluri; 20 pages.*

STAINLESS STEEL PIPE & TUBING



Prevents Corrosion Here...

Insures Product Purity Here

Stainless can eliminate unwanted product contamination and discoloration in process or service lines. Impervious to attack from most commercial reagents, it provides lasting freedom from costly corrosion.

Damascus manufactures a complete line of stainless pipe and tubing in sizes from ½" to 3" O.D. Available in standard A.I.S.I. analyses for normal applications and special metals for extreme corrosive service.

For assistance in selecting the right material for your job, contact Damascus direct—or call your nearest Steel Service Center.

COMPLETE INFORMATION ON RARE AND REACTIVE METALS PIPE AND TUBING

New 44-page handbook contains data on applications, heat treatment, corrosion resistance, chemical and physical analysis, mechanical properties of Zirconium, Zircaloy 2, Zircaloy 3; Titanium, grades 40, 55, and 70; Precipitation Hardening Steels, A-286, 17-7-PH, 15-7-MO; HASTELLOY ALLOYS, A, B, C, F, and X.

DAMASCUS TUBE COMPANY
Greenville, Pa.

Gentlemen: Please send me your new 44-page handbook.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

GREENVILLE, PENNSYLVANIA

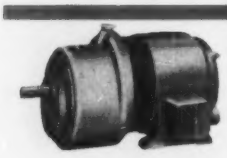
FORGED STEEL TUBE INSTITUTE

AMERICAN STEEL WAREHOUSE ASS'N

Wherever Power is used...

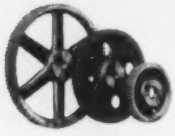
R-TYPE WORM REDUCERS

UNIVERSAL MOUNTING WORM REDUCERS



RITESPEED GEARMOTORS

SHAFT MOUNTED GEAR UNITS



SPUR GEARS

HYDRAULIC COUPLINGS

... you can rely on Crofts

Crofts supply a range of power transmission equipment for every industry where power is used. Over 70 years experience, in design and manufacture enables Crofts to supply the best, at prices worth investigating. To solve your problem of power transmission costs, and for the name of your nearest distributor, write

CROFTS U. S. A. INC.

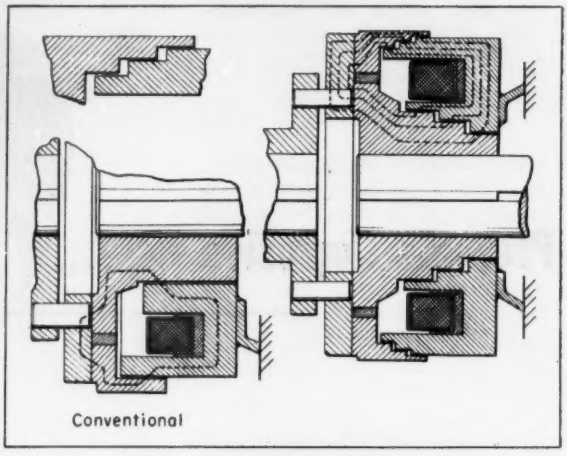
2542 WEST PETERSON AVENUE, CHICAGO 45, ILLINOIS

A few of our products: Ritespeed Gearmotors • Ritespeed Reduction Gears • Worm Gearmotors • Worm Gear Reducers • Helical Gear Reducers • Spur and Bevel Gears • Motor Driven Rollers • Spiral Bevel Gear Units • Hydraulic Couplings • Friction Clutches • Carter Variable Speed Hydraulic Gears • Shaft-mounted Gear Units

NOTEWORTHY

Patents

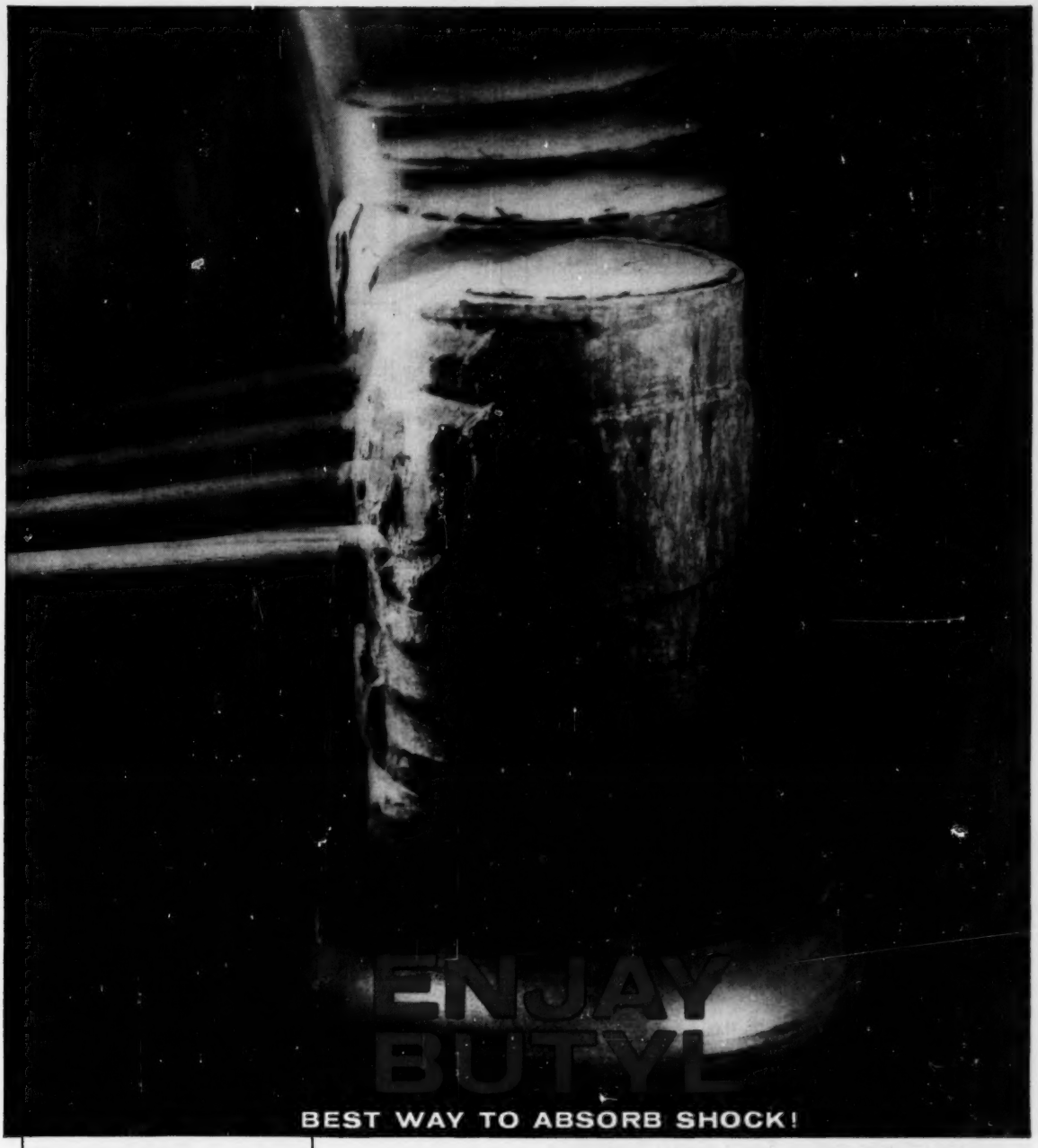
Stepped-Surface Magnetic Clutch

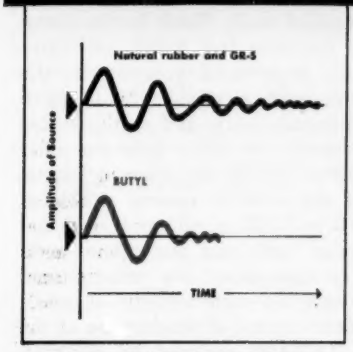


Stepped construction of mating surfaces on input and output assemblies of a magnetic clutch channels flux lines in a way that employs the magnetism more effectively than in conventional straight-sided construction. As a result, the OD of a stepped-construction clutch can be appreciably smaller than the OD of a straight-sided clutch of the same capacity. For maximum effectiveness in a clutch, flux lines should follow a radial path as they pass between the assemblies. To assure this, the steps are designed to break the flux flow into three approximately equal parts; radial clearance is held to a minimum between adjacent steps on the two assemblies; and axial clearance between adjacent step "risers" is made relatively large. Since flux lines pass more easily across the smaller gap, their direction tends to be radial there. *Patent* 2,857,998 *assigned to Warner Electric Brake & Clutch Co., Beloit, Wis., by Paul A. Harter.*

Impact-Resistant Spring Element

A toroidal tube of spring metal, filled with silicone material, functions as a high-load, resilient shim or spacer. The ring maintains a constant thickness under a constant load perpendicular to its plane, yet flexes readily under super-imposed shock loads and regains its loaded section shape and loading characteristics. This performance is maintained over a wide range of environmental temperatures. Inherent resilience of the putty, a nonnewtonian substance commonly called "Bouncing Putty," is a function of the rate of application of load. Slow application causes plastic deformation with very little resilient effect. The opposite occurs in shock loading. As the spring deforms under either loading, change of cross-section area is accom-





Butyl's superior shock absorption characteristics reduce amplitude of bounce in much less time as compared with other rubbers.

Enjay Butyl, because of its higher damping factor, absorbs shock energy *more* completely than any other rubber. Through simple variations in compounding or processing, you can build the right degree of resiliency for your requirements. Butyl is the ideal rubber for motor mounts, load cushions, sound deadener insulation, axle and body bumpers—and other shock, noise and mechanical vibration applications.

Butyl *also* offers outstanding resistance to weathering and sunlight . . . chemicals . . . heat . . . abrasion, tear and flexing . . . unmatched electrical properties and impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY® BUTYL

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

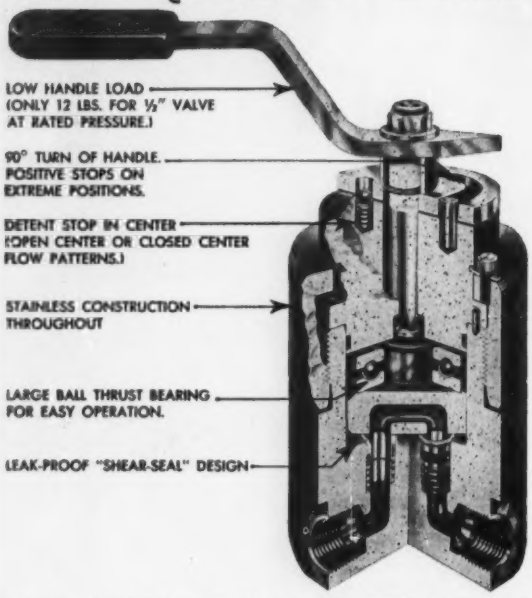
Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Circle 533 on Page 19

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

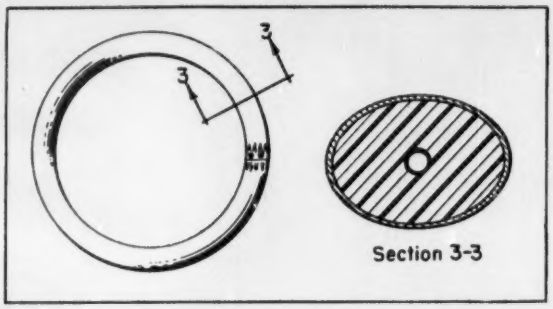
Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 58-59

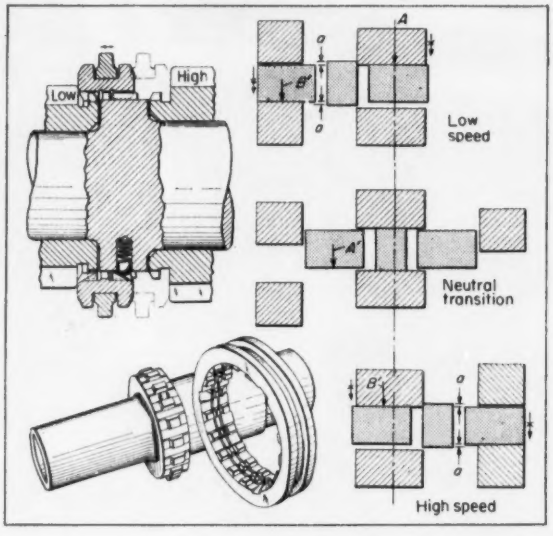
CONTROL VALVE DIVISION **barksdale valves**

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA



modated by flexing of a gas-filled tube in the center of the ring section. *Patent* 2,859,033 *assigned to Hughes Aircraft Co., Culver City, Calif., by James D. Rose.*

Positive-Locking Clutch Collar

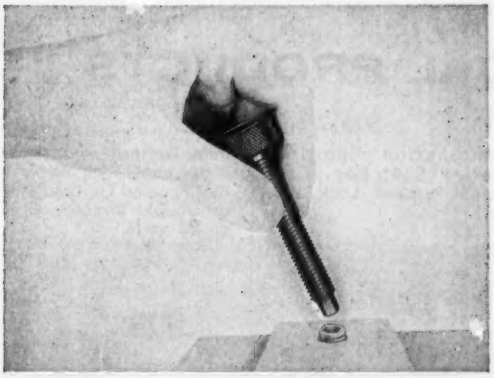


Positive locking in either high or low-speed positions is provided by a difference of thicknesses of internal teeth in a torque-transmission clutch collar. The collar joins high or low-speed gears to a splined projection from a power shaft coaxial with the gears. Annular grooves in the collar ID divide the teeth into three rows. The two outer rows have teeth of equal thickness which transmit applied loads. Teeth in the center row are thicker, have narrower face width, and carry only transitional loads. A powered yoke carries the collar into engagement with a single row of teeth projecting from the adjacent gears, and spring-loaded balls acting on bevels inside the collar hold the collar in outer engaged positions. While the assembly carries torque load, return of the collar to neutral is blocked by an overlap of 0.015 to 0.020 in. (dimension *a*) between the thicker collar teeth and the spline teeth. Disengagement and re-engagement are accomplished when engaging teeth have the same velocity—a condition achieved by operator control of acceleration of the power shaft. *Patent* 2,846,038 *assigned to Rockwell Spring and Axle Co., Coraopolis, Pa., by Nelson R. Brownyer.*

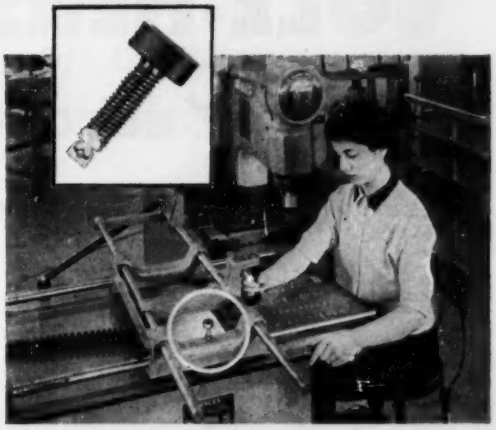
Practical Design Tips

No. 3 of a series

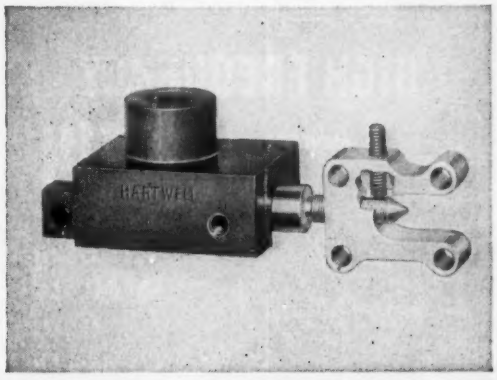
Perhaps the applications shown below will suggest ways you can profit from the use of Vlier tools. Many companies have simplified product design—with resultant savings—by substituting these simple, off-the-shelf items for complicated custom devices.



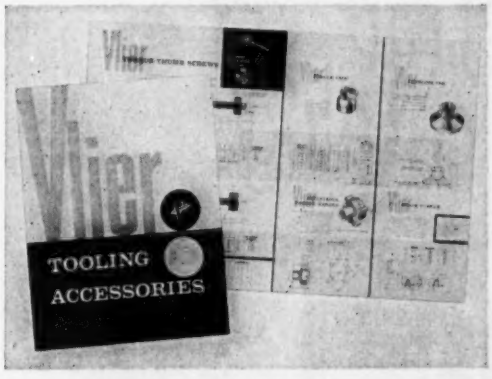
TO LIMIT TORQUE APPLIED TO SOCKET SET SCREWS grind the screw end of a Vlier Torque Thumb Screw to the proper size hex. The amount of torque can be quickly adjusted between 10 lbs. and 125 lbs. Once set torque is reached, knurled ring spins freely, preventing overtightening. Backing off is positive.



TO SECURE THE DUPLICATOR CARRIAGE of this metal fabricating machine when not in use, the manufacturer uses two Vlier Swivel-Pad Torque Thumb Screws. These simple holding tools with the unique ball-joint pad construction, limit the amount of torque which can be applied, and prevent scoring or damage to the ways. Vlier Swivel-Pad Torque Thumb Screws such as used in this application are available in various sizes and end pressures.

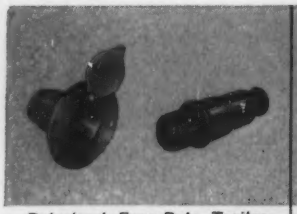


TO PROPERLY POSITION THIS YOKE-SHAPED PART for entrance into a latch assembly, a Vlier S-58 Spring Plunger is used. The threaded stud, extending horizontally, is slotted on two sides. As the stud is rotated, the spring plunger snaps into the slot assuring the proper position of the yoke. Vlier Spring Plungers are available in six nose types; various end pressures.



NEW 1958 CATALOG NOW AVAILABLE—Eight pages; completely revised. Includes information and specifications on all new Vlier products, including the Torque Handle, Stock Pusher, Leveling Pad. Makes ordering easy. Suggests new uses for these proven time-savers. Write for your copy today!

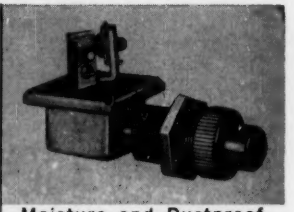
VLIER
Engineering Corporation
A subsidiary of Barry Controls, Inc.
8900 Santa Monica Blvd. • Los Angeles 46, California



Polarized Four-Pole Trailer Connector Assembly for Passenger Cars.

Underwriters' Laboratory Approved Toggle Switches With or Without Wire Leads.

Complete Electrical Control Switch Panel for Electric Starting Requirements.



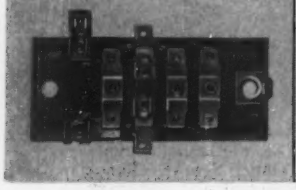
Moisture and Dustproof Momentary Starter or Choke Switch.

COLE-HERSEE

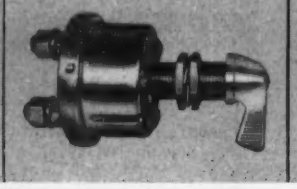
COLE-HERSEE CO.
Over 40 Years of Consistently Better Products
20 OLD COLONY AVENUE, BOSTON 27, MASS.

Quality ELECTRICAL PRODUCTS

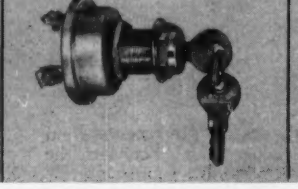
Terminal and Fuse Blocks With Fast Slip-On Type Terminals.



Battery Master Disconnect Switches. Single and Double-Pole Versions.



Combination Ignition Starter Switches With Coded Tumbler Lock and Keys.



Pilot Lamps — Gasketed, Waterproof With Clear or Red Faceted Lenses. Single or Double Contact. 6, 12 or 28 volts.

Circle 536 on Page 19

free catalog

47-page catalog illustrating complete line of

ALLEN AIR

AIR CYLINDERS
AIR VALVES & CLAMPS
DIAL FEED TABLES

The cylinder of "distinction" shown above is a Factory Reject. Only straight rods available.

The A. K. ALLEN CO., 255 East 2nd St., Mineola, N. Y. MU-1

Name _____

Company _____

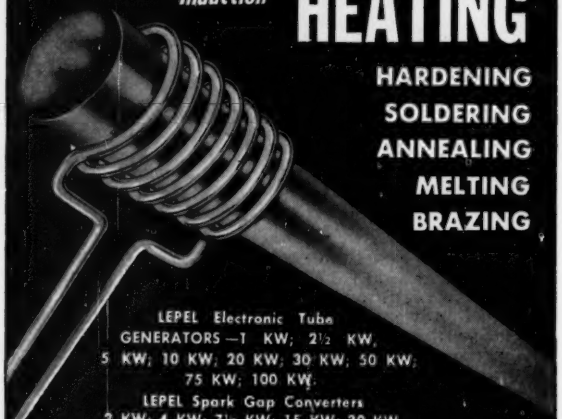
Address _____

City _____ Zone _____ State _____

Lepel

HIGH FREQUENCY *Induction* HEATING

HARDENING
SOLDERING
ANNEALING
MELTING
BRAZING



LEPEL Electronic Tube GENERATORS—1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

Circle 537 on Page 19

Circle 538 on Page 19

push-pull CONTROLS

Compression & Tension Type

Aircraft cable is strung with spherical steel shells in a rigid or fluxible housing sealed with "O" rings. 3" standard bend radius. ¼" minimum bend radius.

Three Types:

1. *Light Duty*—Compression Ult. Load 1250 lbs.; Ult. tension 960 lbs.
2. *Heavy Duty*—Compression Ult. Load 1650 lbs.; Ult. tension 960 lbs.
3. *Extra Heavy Duty*—Compression Ult. Load 3050 lbs.; Ult. tension 3900 lbs.

Positive remote controls for actuating mechanical, hydraulic or other devices. Eliminate bell cranks, pulleys and dual cables. Patented U. S. A. All world rights reserved. Send for ENGINEERING MANUAL giving detailed prints and complete specifications covering materials, finishes, capacities. Please address Dept. MD-PP59.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

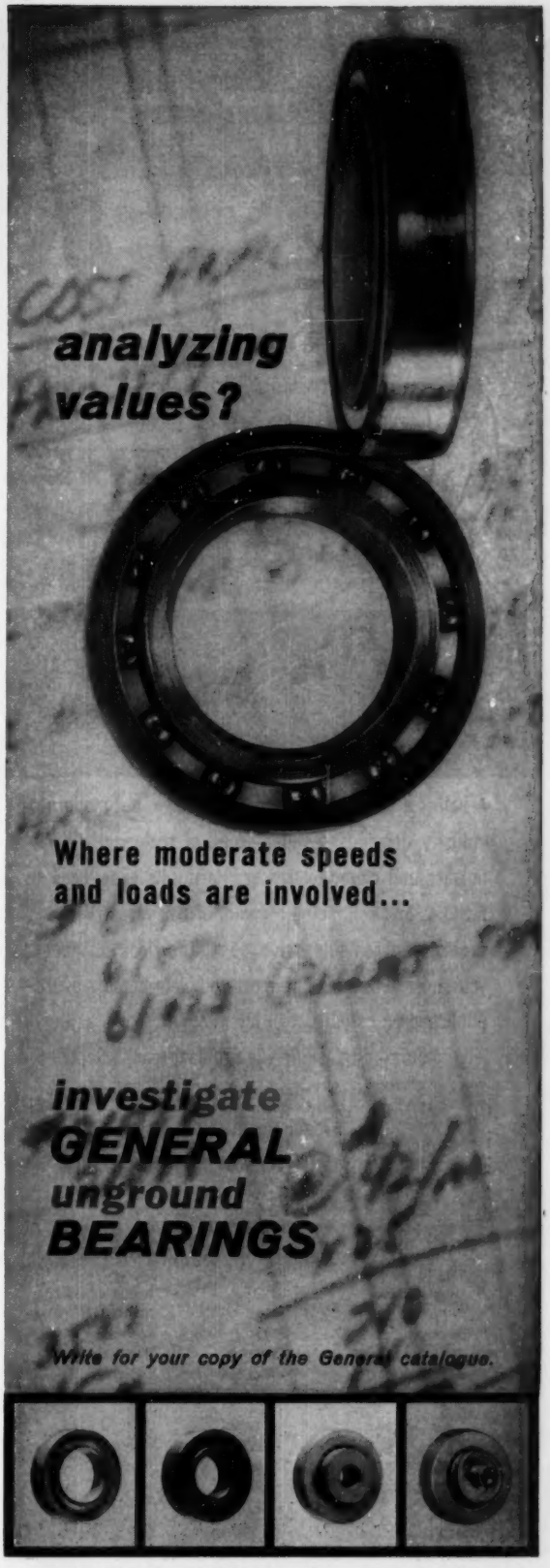
Circle 539 on Page 19

valuable information on molded RUBBER

Know how to specify rubber accurately? This Paeco brochure — plus other free reference material — will give you most of the answers. If rubber is part of your design, this brochure belongs in your files. No charge to designers and engineers.

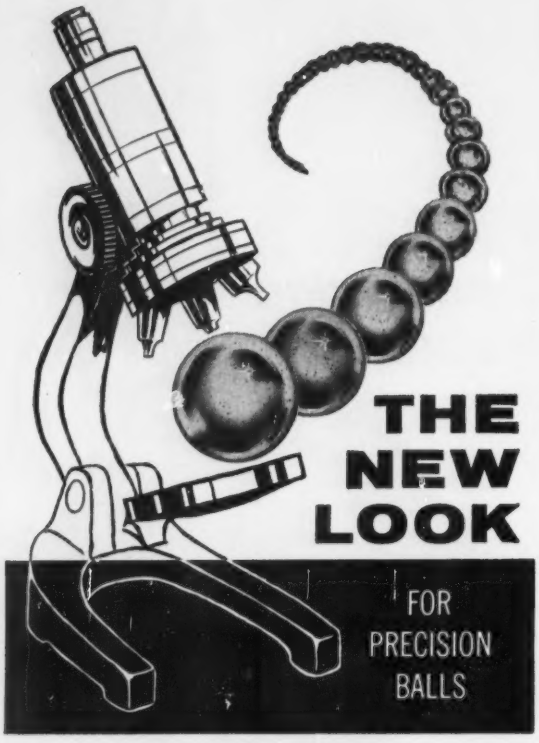
PAECO RUBBER CO.
209 WEST LAKE ST., RAVENNA, OHIO

Circle 540 on Page 19


analyzing values?
Where moderate speeds and loads are involved...
investigate GENERAL unground BEARINGS
Write for your copy of the General catalogue.

GENERAL BEARING COMPANY
61 Roselle Street Mineola, New York

Circle 541 on Page 19



THE NEW LOOK

FOR PRECISION BALLS

A ball is a ball, its shape doesn't change, but modern industry demands a wider scope of materials, finer finishes and closer tolerances. Hartford's experience, facilities and continuing program of ball research and development combine to give you "the new look" to meet your new demands. The most complete catalog ever published on essential ball information (shown at the left) is yours for the asking. It's a guide to quick selection of precision balls for practically any requirement and material selection. Write for your copy today!

HARTFORD LEADS IN BALLS OF ALL MATERIALS

High Carbon Chrome	Glass	Copper
Stainless Steels	Nylon	Beryllium Copper
K-Monel	Teflon	Nickel Silver
Aluminum	Plastic	Cobenium
Naval Brass	Pyroceram	High Speed Steels
Carbon Steel	Gilding Metal	Stellite

Hartford

PRECISION BALLS • BEARINGS

Hartford Steel Ball Co., Inc.,
93 Jefferson Avenue, W. Hartford 6, Conn.

Set Screw Users

Moore offers you a fast, dependable and economical source for one or a million

Moore Set Screws are precision-made and are backed by over 75 years of design-engineering and manufacturing experience. They are of proper hardness for maximum strength and life; they have accurate threads for secure locking action; and they are quality controlled for consistent uniformity. You get fast delivery . . . off the shelf on standard items; two or three-day part shipments on specials.

Improve your product and maintain production schedules with Moore Set Screws. Engineering assistance available.

Moore prices are right . . .
Send for Detailed Price Catalog.

Condensed Specifications

	Headless Slotted	Square Head	Socket Head
Size (dia.)	#0 to ¾"	#6 to ⅜"	#4 to ⅜"
Lengths	1/16 to 3"	3/16 to 2½"	⅛ to 1"
Points	cup, oval, round, flat, cone, dog		
Materials	steel, brass, bronze, stainless, aluminum, alloy steel, monel		

Special Heads — milled, slabbed, double slot, knurled.

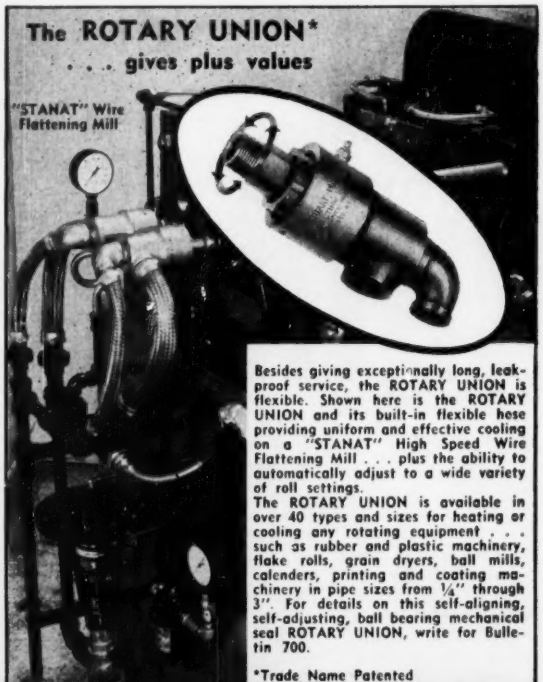
Miniature Headless—#0, #1, #2, #3 sizes in a wide selection of metals, finishes, lengths and points.

MOORE SET SCREWS

George W. Moore, Inc.
since 1880
93 Beaver St., Waltham 54, Mass.

Circle 543 on Page 19

The ROTARY UNION* . . . gives plus values



Besides giving exceptionally long, leak-proof service, the ROTARY UNION is flexible. Shown here is the ROTARY UNION and its built-in flexible hose providing uniform and effective cooling on a "STANAT" High Speed Wire Flattening Mill . . . plus the ability to automatically adjust to a wide variety of roll settings.

The ROTARY UNION is available in over 40 types and sizes for heating or cooling any rotating equipment . . . such as rubber and plastic machinery, flake rolls, grain dryers, ball mills, calenders, printing and coating machinery in pipe sizes from ¼" through 3". For details on this self-aligning, self-adjusting, ball bearing mechanical seal ROTARY UNION, write for Bulletin 700.

*Trade Name Patented

"WHERE *Good Connections* COUNT"

PERFECTING SERVICE COMPANY, 332 Atando Ave., Charlotte, N.C.

Baltimore—Buffalo—Camden, N. J.—Chicago—Cleveland—Los Angeles
New York—Providence—Hamilton, Ont.—Montreal—Toronto

Circle 542 on Page 19

Circle 544 on Page 19

Here's your answer on Motor Blower Assemblies!
Over 20 years of experience in solving Blower problems. Complete stocked line of Motor Blower Assemblies from 4 to 150 CFM. Blowers or impeller wheels available as component parts.
Write for literature.
Superior ... through Research
RIPLEY
ESTABLISHED 1930
RIPLEY COMPANY INC.
MIDDLETOWN, CONNECTICUT

Circle 545 on Page 19

FUNK LICKED THIS 3-WAY PROBLEM

On this Massey-Ferguson Work Bull Multi-Purpose Loader, a FUNK-designed REVERS-O-MATIC DRIVE permits triple operation with one pedal. Instantly changes the speed and direction of travel, leaves hands free for other operations and provides neutral speed control.

And a FUNK TORQUE CONVERTER automatically adjusts power between speed and load requirements.

Just one example of how FUNK MODULAR POWER UNITS can be combined in an unlimited number of arrangements — *without* special engineering costs.

Let FUNK find the solution to *your* power transmission problem.

FUNK MFG. CO. Box 577-F COFFEYVILLE, KANSAS

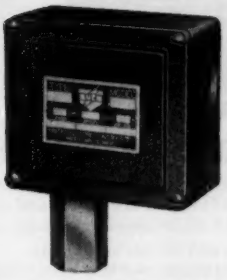
Circle 546 on Page 19

UNITED ELECTRIC

Multi-Purpose

PRESSURE CONTROLS J7 | J40

▶ Enclosed-TYPE J7



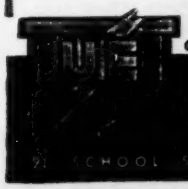
▶ Skeleton-TYPE J40

These controls are compact, precision-built, rugged and inexpensive. Type J7 is ideal for controlling air, gas or liquid pressures up to 500 psi . . . Type J40 for pressures up to 250 psi.

Adjustable Pressure Ranges	J7 . . . various models cover ranges between limits of 0 and 500 psi J40 . . . various models cover ranges between limits of 0 and 250 psi
Switch Ratings	15 amps or 20 amps at 115 or 230 volts A.C., also D.C. switches upon specification
Switch Types	N.C., N.O., or Double throw, no neutral position
Electrical Connections	J7 . . . screw type terminals on switch standard J40 . . . solder type terminals on switch standard
On-Off Switch Differential	Fixed and uniform throughout specified range is standard
Mounting	J7 . . . ¼" NPT female, brass fitting standard J40 . . . ⅛" NPT male, brass fitting standard
Variations	Design variations are available upon specification
Applications	On industrial equipment and engine applications . . . marine, aircraft or special purpose

Although **UNITED ELECTRIC** *offers a complete line of temperature, pressure and vacuum controls . . . UE application engineers specialize in solving unique problems.*

Send for full particulars today. Bulletins available upon request. Type J7 . . . Bulletin No. 5-7, Type J40 . . . Bulletin No. 5-9



United Electric Controls COMPANY

SCHOOL STREET WATERTOWN MASS.

Circle 547 on Page 19

NEW AGASTAT®

HAS LONGER OPERATING LIFE

The Agastat time/delay/relay has been completely re-designed, inside and out, to make every moving part last longer and operate more reliably. Here are some other important advantages:

- Dial adjustment for ease and accuracy
- Five timing ranges, covering an overall range of from 0.08 seconds to 15 minutes
- Timed intervals remain the same through repeated readjustments
- Integral wiring diagram and calibration plate
- Measures only 4-9/16 x 2-9/16 x 2-5/8"
- All contacts are flexible contacts
- Contacts are larger for fast heat dissipation

Write for details and application engineering assistance to Dept. A32-128.

AGA DIVISION

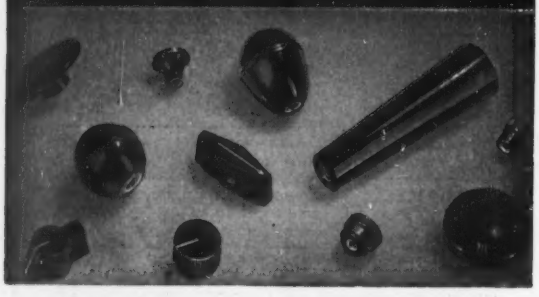
Elastic Stop Nut Corporation of America

1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in Pneumatic Timing

Circle 548 on Page 19

DIMCO-GRAY *Stock plastic* KNOBS...HANDLES



WRITE FOR THIS COMPLETE CATALOG

NO TOOL CHARGE!

Wide selection of stock knobs, handles and plastic parts available without tooling cost to you! Many minor changes (color, design, inserts, threads, special materials, etc.) can be made to meet your requirements.

DIMCO-GRAY COMPANY

204 EAST SIXTH STREET—DAYTON 2, OHIO

Circle 549 on Page 19

HYDRAULIC SERVO FUNDAMENTALS

by J. M. Nightingale

VOL. 1

Covers both the theoretical and practical aspects of servo system design applicable to control systems in general—hydraulic, pneumatic or combined systems.

$1.00 per copy

VOL. 2

Study of the basic servo system components and practical methods for analyzing typical servo systems.

$1.00 per copy

VOL. 3

A detailed approach to methods of improving servo system performance, quantitative design of servo systems and transient response of servo systems.

$1.00 per copy

MACHINE DESIGN
Reader Service
Penton Building
Cleveland 13, Ohio

Send me_____copies of Vol. I @ $1.00 per copy
Send me_____copies of Vol. II @ $1.00 per copy
Send me_____copies of Vol. III @ $1.00 per copy

Remittance or Company Purchase Order must be enclosed with order

NAME _____

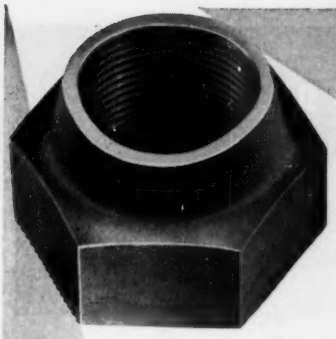
COMPANY _____

ADDRESS _____

CITY _____ ZONE ____ STATE ____

(Add 3% to orders in Ohio to cover State Sales Tax)

New One-Piece
"Conelok"
with prevailing torque



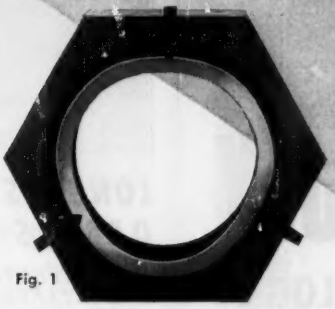


Fig. 1

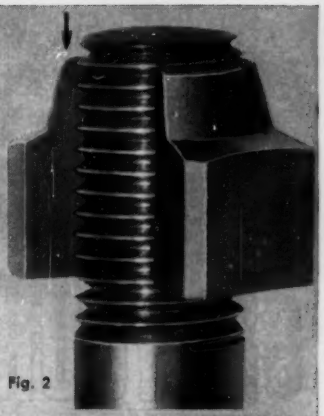


Fig. 2

Three sectors of the tapered portion of the CONELOK nut are preformed inwardly (Fig. 1). When the Nut is applied to a bolt, these conforming sectors are elastically returned to a circular configuration and create an inward and downward pressure which produces intimate contact between the load carrying flanks of the nut and bolt threads (Fig. 2). The shape of the cone sector displacement insures conformity with the mating bolt and maximum friction contact area. . . . The closed stress path in the locking portion of the nut and the advantageous distribution of locking pressure, produce a locking device of high fatigue life . . . and equivalent locking force is exerted at only a fraction of the stress of any slotted type locknut. CONELOK maintains its locking action through many re-applications. . . . It is adaptable to high, and low torque assemblies . . . to high torque stop-nut applications . . . and may be obtained in sizes from No. 10 through 1½", Full and Thick dimensions are "Standard". . .

Send for brochure which includes complete engineering specifications.

NATIONAL MACHINE PRODUCTS COMPANY

an SPS company 44250 UTICA ROAD UTICA, MICHIGAN

Circle 550 on Page 19

THERMOCOUPLES
THAT WILL WITHSTAND
2000°F AND
UP TO 50,000 PSI

LONG LIFE
Sheath Diameters, .04 to .32
Thermocouple Lengths to 50 feet
Complete Thermocouples made to every requirement.

NEW, SIMPLE CONSTRUCTION

A metallic sheath compressed over ceramic insulated wire. Sheath can be bent and weldments can be performed without loss of insulation.

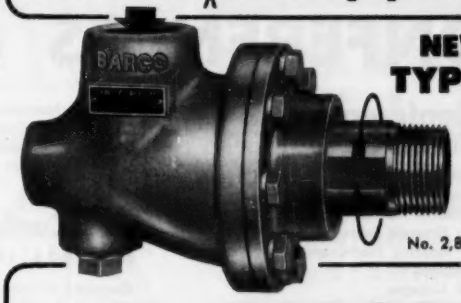
Write for new Bulletins ▶ 3.8A for complete thermocouples. 4 for AEROPAK Ceramic insulated wire.

Aero Research
INSTRUMENT COMPANY, INC.

315 NORTH ABERDEEN • CHICAGO 7, ILL.
Sales Representatives throughout the United States and Canada

Circle 551 on Page 19

Need a *Better* rotary joint?



NEW TYPE C

Patent No. 2,836,439

-it's BARCO!

For countless applications, Barco's new Type C Rotary Joint will give you the best operating records you've ever had—*and for LESS COST!*

"CRACK-FREE" CHROME PLATED SLEEVE—A standard Barco feature. Minimizes corrosion, friction, wear. Stainless steel spring also standard.

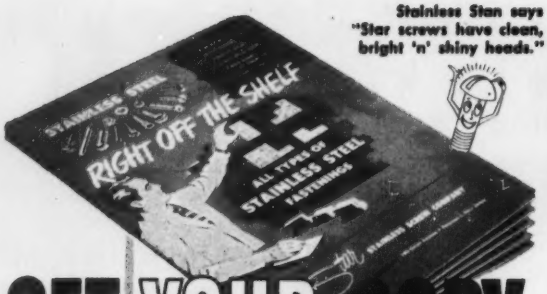
RESISTS SEAL RING BREAKAGE—The spherical seal ring is under compression, not *tension*, loading. Self-adjusting for wear. Seal withstands shock loads and alternating hot and cold service.

WIDE SPACED BEARINGS—Two, instead of one . . . increased bearing area. No lubrication required. Lowest friction.

200 P. S. I. STEAM RATING—Heavy duty service at *no extra cost.* Eight sizes, ½" to 3". *Send for new Catalog 310 today.* **BARCO MANUFACTURING CO., 506-B Hough Street, Barrington, Illinois.**

Circle 552 on Page 19

Stainless Stan says "Star screws have clean, bright 'n' shiny heads."



GET YOUR COPY

STAINLESS STEEL
300 & 400 Series
- AN Drilled Fillisters
- Bolts
- Cap Screws
- Cap, Socket Head
- Cotter Pins
- Dowel Pins
- Hinges
- Machine Screws
- Nuts
- Set Socket
- Sheet Metal Screws
- Stud Bolts
- Taper Pins
- Washers
- Wood Screws

STAR'S CATALOG OF *Right-off-the-Shelf* ® STAINLESS STEEL FASTENERS

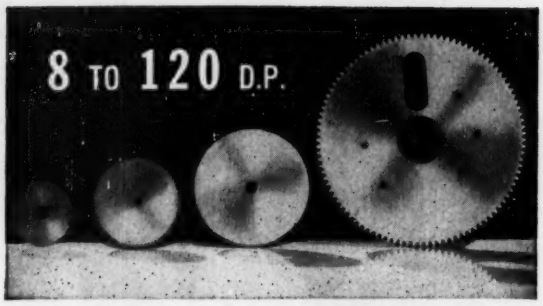
Save time . . . save money. This book lists over 7,000 stainless steel fastenings available for immediate delivery RIGHT OFF THE SHELF®!

Write for catalog on your letterhead TODAY.

CORROSION RESISTANT

STAR STAINLESS SCREW CO.
658 Union Blvd., Paterson 2, N. J.
Telephone CLifford 6-2300
Direct New York City phone: Wisconsin 7-9041
Direct Philadelphia phone: WAlnut 5-3660

Circle 553 on Page 19



LONG LIST OF STOCK GEAR DIES OFFERS YOU BIG SAVINGS!

ACCURATE STAMPED GEARS by *WINZELER* are BIG savers of time and money. Single stampings are laminated to wide faces at savings up to 60%! Further economies are made possible by a BIG range of *stock* Dies. Modern new plant, methods, and equipment now greatly increase production speed, efficiency and *economy!* Send blue prints. Tell us about your needs today. No obligation.

SEND FOR...

New list of WINZELER-made stock Gear Dies. Ask for it on company letterhead, *please!*

WINZELER *Stamped Gears*

WINZELER MANUFACTURING & TOOL CO.
7355 W. WILSON AVENUE • CHICAGO 31, ILLINOIS

Circle 554 on Page 19

MACHINE DESIGN OFFERS REPRINTS OF THE TRANSACTIONS OF THE

CONFERENCES ON MECHANISMS

4th Conference
October 14-15, 1957

Unlocking Human Creativity
Complex Numbers and Four-Bar Linkages
Impact Forces in Mechanisms
Anticipating Dynamic Behavior
High-Speed Indexing Mechanism
Four-Bar Linkages
Slider-Crank Linkages
Alternate Four-Bar Mechanisms
Linkages vs. Cams
Drag-Link Mechanisms
Constant-Load Cam Design
Equivalent Mechanisms for Cams
Mechanism Design in Germany

$2.00 per copy

3rd Conference
May 24-25, 1956

Kinematic Synthesis
Intermittent-Motion Mechanisms
Modified Starwheels
Basic Factors in Cam Design
Practical Approaches to Cam Design

$1.00 per copy

2nd Conference
October 11-12, 1954

Cam Design and Manufacture
Vibration Analysis of Cams
Calculating Dynamic Characteristics of Mechanisms
Analysis of Mechanisms with High-Speed Photography
Predicting Performance of High-Speed Mechanisms
Straight-Line Mechanisms
Proportional Control System
Baveloid Gearing

$1.00 per copy

1st Conference
October 12-13, 1953

Mechanisms and Their Classification
Recognition and Treatment of Acceleration
Application and Design of Noncircular Gears
Utilizing Irregular Gears for Inertia Control
A Simplified Approach to Linkage Design
Designing Cams with Aid of Computers
Systematic Correlation of Motions

$1.00 per copy

ORDER YOUR COPIES TODAY

MACHINE DESIGN READER SERVICE
Penton Building
Cleveland 13, O.

Remittance or Company Purchase Order must be enclosed with order

Send me____ copies of the 1st Conference Transactions
Send me____ copies of the 2nd Conference Transactions
Send me____ copies of the 3rd Conference Transactions
Send me____ copies of the 4th Conference Transactions

NAME
COMPANY
ADDRESS
CITY ZONE STATE

(Add 3% to orders for delivery in Ohio to cover State Sales Tax)

RAE motors

engineered to meet your needs

Careful analysis and testing of your product together with experienced RAE Engineers is your assurance of the best motor for the job. RAE offers outstanding service and quality in a large variety of motors in voltages up to 250, and up to 1/8 H.P. (higher for intermittent duty) with many gear head motor combinations. Let us put our years of motor building experience to work for you.

- AC/DC Universal
- DC Shunt wound
- DC Series wound
- DC Compound wound
- Gear Reduction Motors
- Governor Controlled Motors
- Motors for Rheostat Control

Send for the "RAE" service sheet. It will help you supply the data necessary for recommendations and prices.

Rae MOTOR CORP.
2009 Kewaunee St. • Racine, Wis.

Circle 555 on Page 19

BOOTS BELLOWS • TUBES

ACUSHNET has developed rubber stocks with properties that permit sustained flexibility at unusually high or low temperatures, and high resistance to fluids, greases and gases. Our precision-molded boots, bellows and tubes give enduring protection to moving parts by excluding dirt, water, oil, etc.,—retaining grease, oil, fuel—or performing both functions at the same time over long periods of flexing.

Send For your copy of the Acushnet Rubber Data Handbook

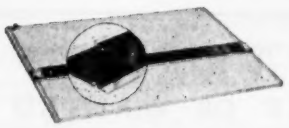
Acushnet PROCESS COMPANY

All items are made to order

Address correspondence to 762 Belleville Ave., New Bedford, Mass.

Circle 556 on Page 19

MAYLINE



The Best Possible Combination

A Mayline straightedge and a Mayline table. Mayline straightedges are made from moisture resistant black satin laminated phenolic plastic. Transparent edges are crystal clear. Available in 30" to 96" lengths. Straightedges completely described in Folder S-15.

These fine straightedges attached to the May-O-Matic table make an incomparable combination. The May-O-Matic top is adjustable for height positioning and required angle of drawing position. It is available in 10 combinations. This amazing table explained in detail in Folder S-22. Send for both folders today.

MAYLINE CO., INC.
601 No. Commerce St.
Sheboygan, Wisconsin

MAYLINE MAYLINE MAYLINE

Circle 557 on Page 19

The ADDED Ingredient... KNOW-HOW—

...HAS MADE
DUDEK & BOCK
THE Leader!

WIRE FORMS
SPRINGS
METAL STAMPINGS

In Industry, in homes, farms and shops, you'll find daily, living proof that D-&-B's KNOW-HOW pays out in EXTRA performance. Rely on expert engineers for parts that meet your *exact* needs and save you MONEY! Get *Wire Forms, Springs* and *Stampings* that are easily assembled . . . that withstand stress . . . and perform under the most *trying* conditions!

Write for FREE Brochure

SPEEDY DELIVERY
WRITE — WIRE — or PHONE for Estimates and Delivery Dates

Phone: DICKENS 2-1020

DUDEK & BOCK SPRING MFG. CO.
4014 W. Grand, Chicago 51, Ill.

Circle 558 on Page 19

Experience on Projects such as:

- JUPITER "C"
- JUPITER
- REDSTONE
- ATLAS
- NIKE
- CORPORAL
- NAVAHOE
- AND OTHERS

Write for illustrated brochure
DEPT. MD
SLIP RING COMPANY OF AMERICA
3612 WEST JEFFERSON BLVD.
LOS ANGELES 16, CALIF.
Sales Engineers throughout the U.S. & Canada

Circle 559 on Page 19

OPPORTUNITIES

. . . With A Growth Company

ENGINEERS

ME's or EE's with 3 to 8 years experience in design and development of complex electro-mechanical machines and equipment.

HALOID XEROX

Kindly send resume and salary requirements to:

FRED A. WETERRINGS

Industrial Relations Division

HALOID XEROX INC.

P.O. Box 1540

ROCHESTER 3, NEW YORK

Circle 560 on Page 19

RESEARCH ENGINEERS

●

Young engineers with M.S. or Ph.D. degrees in Mechanical Engineering or Mechanics are invited to inquire about research positions in analytical mechanics, dynamics of machines, vibration analysis or stress analysis. A good knowledge of applied mathematics and the fundamental principles of mechanics is required. We work on a wide variety of subjects, presently including balancing of flexible rotors, aircraft landing-gear system dynamics, missile and satellite trajectory studies, dynamics of high-speed shafts, and advanced kinematics of mechanisms.

Our staff members enjoy many advantages, not the least of which is an excellent opportunity for advanced study at Illinois Institute of Technology and other universities.

Write us of your interest; we will send you full details.

E. P. Bloch

ARMOUR RESEARCH FOUNDATION

of

Illinois Institute of Technology

10 West 35th Street

Chicago 16, Illinois

Circle 561 on Page 19

ENGINEERS
AVAILABLE OR WANTED

WANTED: Mechanical Development Engineer—Design advanced manufacturing production equipment and systems for widely varying applications. Requires degree in Mechanical Engineering and a minimum of five years' responsible experience in design of medium weight automatic machinery. Additional experience in controls, facilities, planning or automation desirable. Send resume and salary requirements to: R. L. Sauer, Westinghouse Electric Corporation, P. O. Box 2278, Pittsburgh 30, Pennsylvania.

AVAILABLE: Senior Mechanical Design Engineer for board work. Offering you competence, experience and ability on design of product, power press dies, machinery of all kinds, production tools; quality draftsmanship; ingenuity and originality on development of ideas. Per Diem basis. Any location and length of job. Address: Boxholder, 202 Back Bay Postal Annex, Boston, Massachusetts.

Advertising Index

Acme Chain Corporation 169
Acushnet Process Co. 203
Adams & Westlake 168
Aero Research Instrument Co., Inc. 201
A'G'A Division, Elastic Stop Nut Corporation of America 200
Allegheny Ludlum Steel Corporation 173
Allen, A. K., Co., The 196
Allen Manufacturing Co. 21
Allis, Louis, Co., The 76, 77
Amchem Products, Inc. 179
American Brass Co., The, The American Metal Hose Division 5
American Machine and Metals, Inc., United States Gauge Division 172
American Metal Hose Division, The, The American Brass Co. 5
American Nickeloid Co. 158
American-Standard, Ross Heat Exchanger Division 85
American Welding & Manufacturing Co., The.. 102
Anchor Plastics Co., Inc. 161
Armour Research Foundation of Illinois Institute of Technology 204
Automotive Gear Division, Eaton Manufacturing Co. 16

Babcock & Wilcox Co., Tubular Products Division 208
Baldor Electric Co. 189
Barco Manufacturing Co. 201
Barden Corporation, The 83
Barksdale Valves, Control Valve Division 194
Bethlehem Steel Co. 92
Bijur Lubricating Corporation 176
Buffalo Forge Co. 71
Bunting Brass and Bronze Co., The 155

Carpenter Steel Co., The, Alloy Tube Division 98
Celanese Corporation of America, Chemical Division 75
Central Foundry Division, General Motors Corporation 60, 61
Chrysler Corporation, Amplex Division 63
Cincinnati Gear Co., The 35
Cole-Hersee Co. 196
Commercial Filters Corporation 31
Commercial Stamping & Shearing Co. 175
Conway Clutch Co., The 58
Copperweld Steel Co., Ohio Seamless Tube Division 153
Cramer Controls Corporation 143
Crane Packing Co. 37
Crofts U. S. A. Inc. 192
Crucible Steel Company of America 80, 81
Cutler-Hammer, Inc. ..... Back Cover

Damascus Tube Co. 191
Dimco-Gray Co. 200
Dodge Manufacturing Corporation 48
Dudek & Bock Spring Mfg. Co. 203
Durez Plastics Division, Hooker Chemical Corporation 167

Eastern Industries, Inc. .... Inside Front Cover
Eaton Manufacturing Co., Automotive Gear Division 16
Elastic Stop Nut Corporation of America, A'G'A Division 200
Electro Devices, Inc., Servospeed Division .. 166
Enjay Co., Inc. 193

Farval Corporation, The .... Inside Back Cover
Federal-Mogul-Bower Bearings, Inc., National Seal Division 84
Funk Mfg. Co. 199

Garlock Packing Co., The 87
Gates Rubber Co., The 42, 43
General Aniline & Film Corporation, Ozalid Division 56
General Bearing Co. 197
General Electric Co. 38, 39
General Motors Corporation, Central Foundry Division 60, 61
General Motors Corporation, New Departure Division 11
General Plate Division, Metals & Controls Corporation 62
Gleason Works 27
Goodrich, B. F., Co., The, Aviation Products Division 64
Goodyear Tire & Rubber Co., Industrial Products Division 2
Gries Reproducer Corporation 182
Groov-Pin Corporation 68

Haloid Xerox Inc. 204
Hanna Engineering Works 33
Hannifin Co., A Division of Parker-Hannifin Corporation 69, 70
Hansen Mfg. Co., Inc. 96
Hartford Steel Ball Co., Inc. 198
Haynes Stellite Co., Division of Union Carbide Corporation 54, 55
Helo-Krome Screw Corporation, The 149
Holtzer-Cabot Motor Division, National Pneumatic Co., Inc. 174
Hooker Chemical Corporation, Durez Plastics Division 167
Hubbell, Harvey, Inc. 170

Industrial Timer Corporation 74
Inland Steel Co. 103

Johnson, Carlyle, Machine Co., The 185
Jones & Laughlin Steel Corporation 49, 50, 51, 52

Kauffel & Esser Co. 177
Koppers Co., Inc. 53

Lamson & Sessions Co. 104
Landis & Gyr, Inc. 146
Lepel High Frequency Laboratories, Inc. 196
Link-Belt Co. 57
Lovejoy Flexible Coupling Co. 152
Luzerne Rubber Co. 168

McGill Manufacturing Co., Inc., Bearing Division 90

Mac Lean-Fogg Lock Nut Co. 34
Malleable Castings Council 88, 89

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

MARY L. CALLAHAN
Advertising Service Manager

RICHARD A. TEMPLETON
Research and Circulation Manager

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE, EDWARD F. CLANCY
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
CHARLES F. REINER
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5560

Griffin, Ga. .....1106 Pine Valley Rd.
FRED J. ALLEN
Griffin 7854

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND
(Clearwater) 39-9493

Dallas 35 .....818 Exchange Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523

London, S.W.1 .....2 Caxton St., Westminster

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYS .....Chairman
R. C. JAENKE .....President
F. G. STEINEBACH ....Vice President and Secy.
F. O. RICE .....Vice President
J. P. LIPKA..Treasurer and Assistant Secretary

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1958 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

HOW ABOUT YOU?

Do you know that many cancers can be cured if detected early? That an annual health checkup is your best protection against cancer?

Are you giving yourself this big advantage? Or are you taking chances with your life because of foolish attitudes about cancer like these?

DON'T EVEN MENTION THAT WORD!

Fear keeps some people from even *learning* cancer facts that can save their lives.

NEVER FELT BETTER!

Checkups help to detect cancer in its "silent" stage before you notice any symptom.

COSTS TOO MUCH!

Dollars you spend for the protection of your health can mean years of life.

Millions of Americans have made an annual checkup a habit... *for life.* How about you?

AMERICAN CANCER SOCIETY

Advertising Index

Mayline Co., Inc. 203
Metals & Controls Corporation, General Plate Division 62
Midvale-Heppenstall Co. 28
Milford Rivet & Machine Co., The 32
Minneapolis-Honeywell 65
Modernair Corporation 40
Molded Fiber Glass Co. 148
Moore, George W., Inc. 198
Morse Chain Co. 46, 47
MPB, Inc., Split Ballbearing Division 164
Mueller Brass Co. 72, 73

National Machine Products Co. 201
National Pneumatic Co., Inc., Holtzer-Cabot Motor Division 174
National Seal Division, Federal-Mogul-Bower Bearings, Inc. 84
New Departure Division of General Motors Corporation 11
Nordgren, C. A., Co. 99

Ohio Seamless Tube Division of Copperweld Steel Co. 153
Ohmite Manufacturing Co. 45
Oilgear Co., The 7
O'Neil-Irwin Mfg. Co. 148
Orthman Miller Machine Co. 93
Ozalid, A Division of General Aniline & Film Corporation 56

Pasco Rubber Co. 197
Parker Fittings and Hose Division, A Division of Parker-Hannifin Corporation 69, 70
Parker-Hannifin Corporation 69, 70, 82
Parker Seal Co., A Division of Parker-Hannifin Corporation 82
Parker White Metal Co. 163
Perfecting Service Co. 198
Perkins Machine and Gear Co. 162
Pittsburgh Steel Co. 94, 95
Post, Frederick, Co. 15
Potter & Brumfield, Inc. 159

Rae Motor Corporation 203
Reeves Pulley Co., Division of Reliance Electric and Engineering Co. 36
Reliance Electric and Engineering Co., Reeves Pulley Co. Division 36
Ripley Co., Inc. 199
Robbins & Myers, Inc. 66, 67
Ross Heat Exchanger Division, American-Standard 85
Ross Operating Valve Co. 1

Schrader's, A., Son, Division of Scovill Mfg. Co., Inc. 86
Scovill Mfg. Co., Inc., A. Schrader's Son Division 86
Servospeed, Division of Electro Devices, Inc. 166
Servo-Tek Products Co. 161
Sewall, E. B., Manufacturing Co. 41
Skinner Electric Valve Division 157
Slip Ring Company of America 204
Southwest Products Co. 197
Spectrol Electronics Corporation 170
Sperry Rand Corporation, Vickers Electric Products Division 146
Sperry Rand Corporation, Vickers, Inc., Division 9
Spharco, Sealmaster Bearing Division, Stephens-Adamson Mfg. Co. 166
Split Ballbearing, A Division of MPB, Inc... 164
Square D Co. 91
Stacer Equipment Co. 184
Standard Pressed Steel Co., Unbrako Socket Screw Division 100
Standard Screw Co. 160
Star Stainless Screw Co. 202
Stephens-Adamson Mfg. Co., Spharco, Sealmaster Bearing Division 166
Superior Tube Co. 78

Thomson Industries, Inc. 147
Timken Roller Bearing Co., The, Steel and Tube Division 59
Tomkins-Johnson Co., The 97
Torrington Co., The 13
Twin Disc Clutch Co. 151

Union Carbide Corporation, Haynes Stellite Division 54, 55
Union Chain and Manufacturing Co., The 156
United Electric Controls Co. 199
United States Gauge, Division of American Machine and Metals, Inc. 172
United States Graphite Co., The, Division of The Wickes Corporation 101

Valvair Corporation 145
Vickers Electric Products Division, Vickers, Inc., Division of Sperry Rand Corporation 146
Vickers, Inc., Division of Sperry Rand Corporation 9
Viking Pump Co. 178
Vlier Engineering Corporation 195
Vulcan Electric Co. 152

Wagner Electric Corporation 154
Waldes Kohinoor, Inc. 79
Ward Leonard Electric Co. 183
Washington Steel Corporation 187
Wheelock, Lovejoy & Co., Inc. 165
White, S. S., Industrial Division 181
Wickes Corporation, The, The United States Graphite Co. Division 101
Winzeler Manufacturing & Tool Co. 202
Wood's, T. B., Sons, Co. 171
Wyman-Gordon Co. 44

Engineers Available or Wanted 204

NOW AVAILABLE

MACHINE DESIGN Data Sheets

The repeated requests for reprints of MACHINE DESIGN's Data Sheets has resulted in the collection of this useful information into handy, compact manuals. Each manual contains the complete set of Data Sheets appearing in MACHINE DESIGN during a single year. This excellent source of engineering information provides a constant reference for engineers seeking valuable short cuts to design problems. Each manual sells for only $2.00 per copy yet pays big dividends in time saved.

1957 DATA SHEETS INCLUDE:

Galvanic Corrosion
By Harold Blye—January 10

Pipe Bends
By D. S. Davis—January 24

Vibration Frequency Charts
By J. N. Macduff and R. P. Felgar—February 7

Cubic Equations
By G. L. Sullivan—February 21

Thermal Expansion of Materials
By V. H. Hayes—March 7

Corner Angles
By Victor W. Bolie—March 21

Pressurized Cylinders and Spheres
By B. Seelman—April 4

Nonuniform Beams
By R. A. DiTaranto—April 18

Bolt-Hole Circles
By Donald E. Sweet—May 2

Moments of Inertia
By Ricardo Chicurel—May 16

Endurance Limits
By Alex B. Carr—May 30

States of Stress
By John O. Predale—June 13

Finding Areas
By M. Deha Korkut—June 27

Stress in Rotating Cylinders
By E. V. Garner—July 11

Helical Compression Springs
By John H. Keyes—July 25

Preferred Gear Sizes
By Gustav A. Larson—August 8

Modified-Trapezoid Cam Profiles
By Viktoras Bilaisis—August 22

Socket-Head Cap Screws
By Ralph W. Dicely and H. J. Long—September 5

Elastic Mounting Pads
By Alex Cowie—September 19

Natural Frequencies of Beams
By R. A. DiTaranto—October 3

Graphical Integration
By J. Wolak—October 17

Tangent Circles
By James D. Rutter—October 31

Deflection of Circular Rings
By H. D. Tabakman—November 14

Irregular Areas
By William G. Flannelly—November 28

Kinematic Viscosity and Reynold's Number
By Kenneth A. Merz—December 12

States of Stress
By E. W. Suppiger—December 26

1956 DATA SHEETS INCLUDE:

Cycloidal-Motion Cams
By George F. Kennison—January12

Cantilever Beams
By Donald Marshall—January 26

Beam Deflection
By H. H. Mable—February 9

Pressurized Cylinders
By Herbert A. Magnus—February 23

Pressurized Square Tubing
By A. J. Durelli and J. B. Barriage—March 8

V-Belt Drive Bearing Loads
By L. T. Brueggeman—March 22

Physical Mechanics
By George H. Logan—April 5

Helical Compression Springs
By Edwin F. Smith—April 19

Involute Gear Tooth Layout
By Harold M. Durham—May 3

Principal Stresses
By E. C. Appleby—May 17

Basic Cam Systems
By Harold A. Rothbart—May 31

Brake Design
By Reiner J. Auman—June 14

Tapping Screws for Plastics
By Walton Yerger and Stuart Bego—June 28

Hydraulic Pumps and Motors
By Howell C. Lowe—July 12

Blind Tapped Holes
By P. A. Unverzagt—July 26

Stepped and Tapered Shafts
By Alexander Cowie—August 9

Fastener Finishes
By Walton R. Yerger—August 23

Areas of Circle Segments
By R. J. Keery—September 6

Round Tubes in Bending
By B. Seelman—September 20

Pressure Losses in Hydraulic Lines
By E. H. Gatwood—October 4

Rectangular and Elliptical Tubes
By B. Seelman—October 18

Tapered Cantilever Beams
By Durward Cason—November 1

Bolted Flange Joints
By B. B. Clements—November 15

Epicyclic Gear Systems
By H. G. Laughlin, A. R. Heiwenke and A. S. Hall—November 29

Column Design
By A. L. Gosman, F. R. Campbell and R. P. Bebco—December 13

Geneva Mechanisms
By Sol Dudnick—December 27

- ★ **Invaluable to engineers**
- ★ **Practical and technical**
- ★ **Ready reference**
- ★ **Time saving**

These worthwhile Data Sheet manuals are the only ones of their kind available. They provide a compact guide to being fully informed on current design-engineering trends and techniques. Order a set today for your department or personal library. Use the convenient form for prompt service.

MACHINE DESIGN
READER SERVICE

(Remittance or Company Purchase Order must be enclosed with order)

Penton Bldg.
Cleveland 13, Ohio

Please send me_____copies of the 1956 Data Sheets @ $2.00 per copy

Please send me_____copies of the 1957 Data Sheets @ $2.00 per copy

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ **ZONE** _____ **STATE** _____

(Add 3% to orders in Ohio to cover State Sales Tax)

MACHINE DESIGN • Data Sheet

ORDER TODAY

"B&W Welded Tubing with special smooth ID finish keeps my fabrication problems to a minimum!

As a design engineer for hydraulic applications, I find that B&W Welded Carbon Steel Mechanical Tubing with special smooth ID finish offers outstanding benefits. The finished condition in which it comes to our plant reduces costs by eliminating a number of fabricating operations."

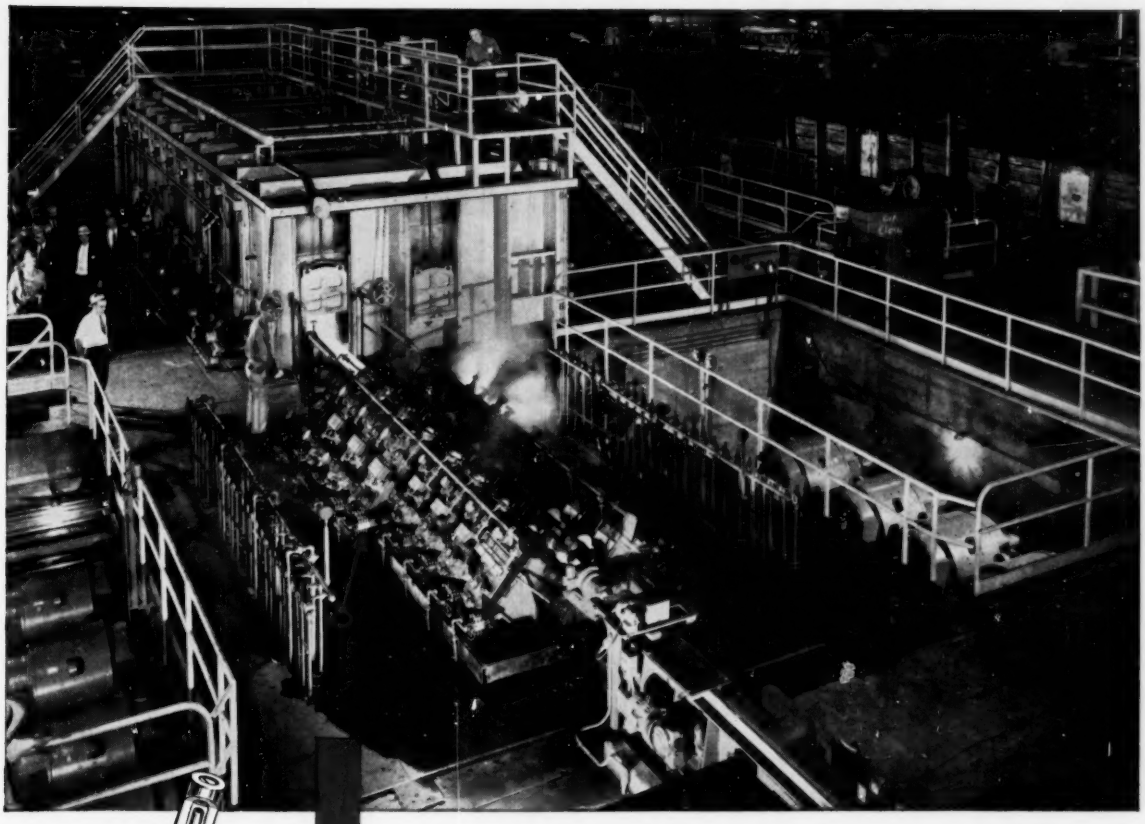
The uniform finish of this type of tubing means that for many hydraulic applications it can be used "as received" from the mill—eliminating such operations as grinding and polishing. Continuous quality control through every manufacturing operation—with ultrasonic testing supplementing accepted methods of inspection—makes sure that you get tubes matched to your end-use application.

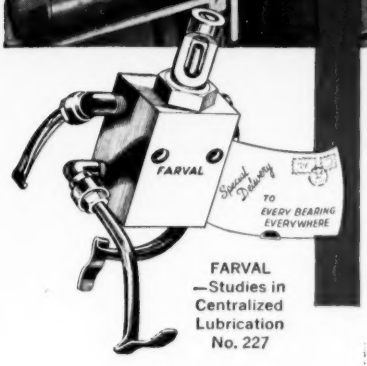
Ask Mr. Tubes, the B&W specialist—he can help you with any tube problem—or write for bulletin TB-428. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

B&W
TUBULAR PRODUCTS DIVISION

TA-8009-M2

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.





FARVAL
—Studies in
Centralized
Lubrication
No. 227

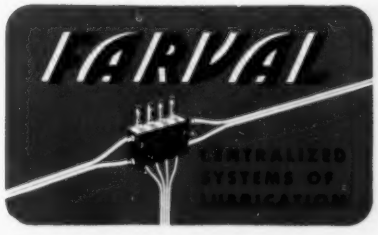
Farval protects bearings as tubing is reduced from 7 to 2 inches

ON this 16-stand Aetna-Standard tube stretch reducing mill, bearings take tremendous pressures as cherry red tubing is reduced from 7 to 2 inches in diameter. And lubricating those essential components is a Farval centralized system delivering measured amount of lubricant at set intervals to every bearing. These bearings are lubricated automatically and safely while the mill is actually in operation.

For bearing protection on your machinery, check with Farval for lubrication. For specifications and drawings, ask for Bulletin 26-S. Write The Farval Corporation, 3287 East 80th Street, Cleveland 4, Ohio.

KEYS TO ADEQUATE LUBRICATION

—wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.



Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

Circle 402 on Page 19

New CUTLER-HAMMER Synchronous Timers Set the Pace in Industrial Control Timer Design and Performance

One minute timer: Adjustable in one second increments, 0 to 60 seconds.

Three minute timer: Adjustable in three second increments, 0 to 180 seconds.

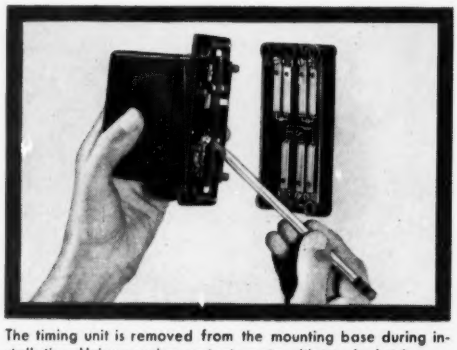
Five minute timer: Adjustable in five second intervals, 0 to 300 seconds.

All three timers are dimensionally identical and feature an exclusive combined terminal board and mounting base. This unique design provides more working-room during installation and on-the-job interchangeability of the timing units without disturbing the mounting base or wiring.

The timer dial reads directly in seconds and one glance shows the exact time delay setting. These timers are simple to set too. Just rotate the bronze pointer to the dial position indicating the precise elapsed time desired and the job is done . . . no approximations or tedious readjustments necessary.

The sweep-second pointer counts off the seconds during each timing cycle. Automatic reset returns the pointer to the start position after each cycle or if a power interruption occurs while in operation . . . no undertimed cycles possible.

These synchronous motor driven timers work better and last longer too. Dust, dirt, and atmospheric conditions can't interfere with the timing mechanism. For further information, write today for Bulletin 10336 A-**243.** CUTLER-HAMMER Inc., Milwaukee 1, Wisconsin.



The timing unit is removed from the mounting base during installation. Unique spring contacts mate with terminal strips . . . no inter-wiring necessary. The one, three, and five minute timing units are all the same size and easily interchangeable without disturbing mounting base or wiring.

CUTLER·HAMMER
CONTROL
C-H

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation

Circle 403 on Page 19